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MOXEE DRAIN BMP IMPLEMENTATION DEMONSTRATION PROJECT WATER QUALITY MONITORING REPORT

by
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ABSTRACT

Implementation of best management practices (BMPs) on irrigated agricultural lands can reduce non-point source pollution (NPS) and improve the quality of irrigation tailwater and receiving waters by reducing soil erosion. The North Yakima Conservation District developed a BMP Demonstration Project in a sub-basin of the Moxee Drain watershed in order to demonstrate the benefits of BMPs to water quality. Water quality monitoring was carried out before, during, and after BMPs were implemented within two drainages in the project area where furrow-irrigated hops and sprinkler-irrigated orchards were the dominant land use. The primary objective of the study was to associate water quality benefits to BMP implementation. Approximately 18 samples per site were collected at multiple sites during each irrigation season in 1991 and 1992. Sample analyses included suspended and settleable solids, turbidity, and nutrients. Pesticides were characterized in samples taken from irrigation tailwater and tailwater sediment.

Findings suggest that project BMPs were effective in improving water quality. Climatic factors leading to a 42% reduction in irrigation water supply between 1991 and 1992 appear to have also contributed to improved water quality, which confounded the "before/after" BMP evaluation strategy used in this study. Large changes in pollutant concentrations and loads (generally greater than 50%) needed to occur before they could be deemed statistically significant. Best management practices were implemented on 917 acres, or about 87% of the project's irrigated lands. Runoff from the lower drainage contributed the most useful water quality information, where BMPs were implemented on 257 acres of furrow-irrigated hops (70% of the lower drainage).

Median pollutant reductions at the lower drainage site (D1) were realized for total suspended solids (TSS) - 86%, TSS load - 90%, Imhoff settleable solids (SS) - 99%, nephelometric turbidity - 63%, absorbtometric turbidity - 75%, ammonia - 56%, and ammonia load - 60%. An 18% reduction in the median flow was not significant. Median pollutant reductions at a comparable site (M1) draining non-BMP croplands were realized for Imhoff SS -93%, nephelometric turbidity - 52%, and absorbtometric turbidity - 48%. A 28% reduction in median flow at site M1 was statistically significant. Roza Canal (upper drainage) monitoring did not yield useful data for determining the effectiveness of BMPs.

Pesticides detected in tailwater and tailwater sediments were similar to those detected by other investigators in the Moxee Drain area. Concentrations of DDT compounds from this and other studies exceeded Washington State water quality standards for freshwater chronic effects on aquatic biota.

INTRODUCTION

Background

Each year, excess irrigation water removes significant quantities of soil from irrigated farmland. Irrigation return flows carry soil resources and a variety of agricultural chemicals to rivers and streams draining agricultural areas. The result is a loss of soil resources, both for the farmer and the general public. Not only are soil, nutrients, and chemicals lost from the land but receiving water quality may be degraded as well (Ecology, 1979).

The solution to the long recognized problem of irrigated agriculture pollution is complex. After passage of the Federal Water Pollution Control Act Amendments of 1972, irrigation return flow was classified as "point source" pollution, thus requiring a National Pollutant Discharge Elimination System (NPDES) permit. By 1977, the Environmental Protection Agency (EPA) and the states recognized that an NPDES permit program for irrigation return flows had too many constraints, and that effective pollutant reduction would better be achieved through the use of Best Management Practices (BMPs) on individual farm properties. Irrigation return flows were then reclassified as "nonpoint" source pollution and placed under Section 208 of the Clean Water Act. The Section 208 planning process resulted in a program of voluntary farmer participation to reduce water pollution caused by return flows. Since adoption of Washington's 208 plan, neither the voluntary or regulatory elements have been fully implemented because of inadequate funding (Ecology, 1992).

In 1977, EPA recognized that research was needed to develop and demonstrate the effectiveness of BMPs and alternative practices on water quality (King *et al.*, 1984). To fill this need, EPA supported "Demonstration Projects" designed to evaluate BMP effectiveness. Demonstration projects also explored institutional roles and mechanisms to gain voluntary cooperation from farmers for implementing BMPs on agricultural lands. Two early demonstration projects in Washington addressed water quality problems caused by irrigation return flows:

1. The South Yakima Conservation District Model Implementation Project (SYCD-MIP) became one of seven model projects nationwide, and was the only one that addressed irrigation return flows. The Sulphur Creek and Granger Drain basins were areas of focus for the 1979 to 1981 irrigation seasons. This pioneering project found that three years was an inadequate time period to evaluate the effectiveness of such a project, and suggested that four or five years be allocated instead (SYCD, 1982).

2. The Quincy Columbia Basin Irrigation District Project researched BMPs and water quality from 1977 to 1981, before and after BMPs were installed. Findings from this predominantly furrow-irrigated area in central Washington concluded that on-farm sediment basins reduced sediment discharge from fields by an average of 66%, and that reduced sediment discharge doesn't necessarily accomplish phosphorus reduction (King, *et al.*, 1984).

Other demonstration projects have since been completed that assessed a variety of irrigation practices and their impacts on water quality. Building on previous work, the North Yakima Conservation District (NYCD) in 1989 began a two-year water quality project that included developing and demonstrating furrow mulching (placement of straw in irrigation furrows) as a BMP to reduce erosion in furrow irrigated fields of hops and grapes. Water quality benefits of this practice appeared to be substantial as determined by end-of-furrow water quality monitoring (NYCD, 1992). Pollutant reductions from individual furrow tailwaters reported were: sediment - 90%; phosphorus - 70%; and nitrogen - 62% (Ecology, 1992). Furrow mulching appeared to be a practice that had rewards for both the farmer and water quality. A cost-benefit analysis from this project reported that $6.45 was returned to the producer for each $1.00 spent on furrow mulching, 85% of which was attributed to increased crop yields (Anderson & Associates, 1993).

To expand on the furrow mulching concept, NYCD developed a BMP demonstration project in 1991 on an irrigated sub-basin of the Moxee Drain. The goal of the Moxee Drain BMP Implementation Demonstration Project was to demonstrate water quality benefits associated with basin-wide implementation of BMPs. The sub-basin was chosen because it was representative of irrigated agricultural practices in the larger Moxee Drain basin, and a high rate of participation by landowners was anticipated. BMP implementation was projected for 75% of the agricultural land in the sub-basin. Ecology's Water Quality Program requested that the water quality monitoring component to this project be cooperatively designed and implemented by the Watershed Assessments Section of Ecology's Environmental Investigations and Laboratory Services Program, in collaboration with NYCD. Both the BMP demonstration project and the water quality monitoring program were funded through separate Clean Water Act Section 319 grants. Final reports from each effort were combined under one cover by NYCD: Part 1 is NYCD's report on BMP implementation and Part 2 (this report) is Ecology's water quality evaluation of the project. Ecology's report (Part 2) was also published separately in order to meet grant requirements.

Water quality data were collected during the 1991 and 1992 irrigation seasons in order to attain the following objectives:

1. Evaluate the effectiveness of collective BMP implementation on the quality of irrigation tailwater and receiving waters.

2. Characterize pesticides in water and sediments from a tailwater drain.

3. Provide data for longer-term assessment of BMP effectiveness related to water quality and transport of sediments, nutrients, and pesticides.

4. Provide information regarding water quality to the agricultural community in the study area and within the North Yakima Conservation District.

The project area is located on the south side of the Moxee Drain at the base of Elephant Mountain, just southeast of Moxee City in Yakima County. The Moxee Drain joins the Yakima

River at Union Gap (RM 107.5) and is one of several agricultural drains that contribute pollutants to the Yakima River. The approximately 1,250 acre sub-basin consists of two major drainages (Figure 1) of which 1,057 acres are irrigated agricultural land. The lower area drains to the Moxee Drain at sample site D1 and consists of about 370 acres of furrow-irrigated hops. The upper area drains to the Roza Canal and is mostly orchard, with some hops and hay fields. A large poultry operation is also located in the upper basin and is adjacent to the Roza Canal. Minor portions of the project sub-basin drain to the Selah-Moxee Canal and the Moxee Drain directly.

Project BMPs were designed to improve water quality by reducing erosion and tailwater quantity. BMPs were implemented on furrow-irrigated hops fields and sprinkler-irrigated orchards. BMPs implemented during the project included: sediment settling basins, furrow-mulching of hops fields, irrigation water management (IWM) through structural and management practices, reduced tillage, and cover cropping. Management of nutrients or pesticides was not directly addressed through farm planning or BMPs.

Study Design

The study was designed to monitor water quality during a pre-BMP growing season (1991) and during the following growing season (1992) when BMPs were being implemented. NYCD identified three different periods within the growing season and one off-season period to target for sampling because of varying crop culture and irrigation practices. Three consecutive weeks within each period were monitored. Two separate samples were collected each week (on consecutive days), yielding six samples per period, for 18 samples per station for each irrigation season. NYCD supplemented this schedule by sampling for flow, absorbtometric turbidity, and Imhoff settleable solids on other dates during and after the irrigation season. Targeted periods within the growing season are described below:

- The first or "early" period starts in April when irrigation of crops begins, and continues through early May. Irrigation requirements for hops and other crops are relatively low at this time of the year. Sediment loading of tailwater (and ultimately the receiving water) has been observed to be high during this initial start-up period due to various field preparation activities such as discing, furrowing, and initial irrigations.

- The next or "middle" period is from mid-May to the end of June. Irrigation requirements are greater than the previous month. Crops are irrigated on a regular cycle, and many cultural practices occur on the fields that involve equipment and the potential for continued sediment loading of irrigation tailwater.

- The final or "late" period begins after July 4 and runs until the harvest of hops during the first or second week of August. This period (known locally as "layby") is characterized by heavy irrigation and absence of equipment on hops fields. Tailwater flows are generally highest during this period. Hops irrigation continues after harvest into September and October to raise soil moisture for the winter. Minimal irrigation of other crops continues through October.

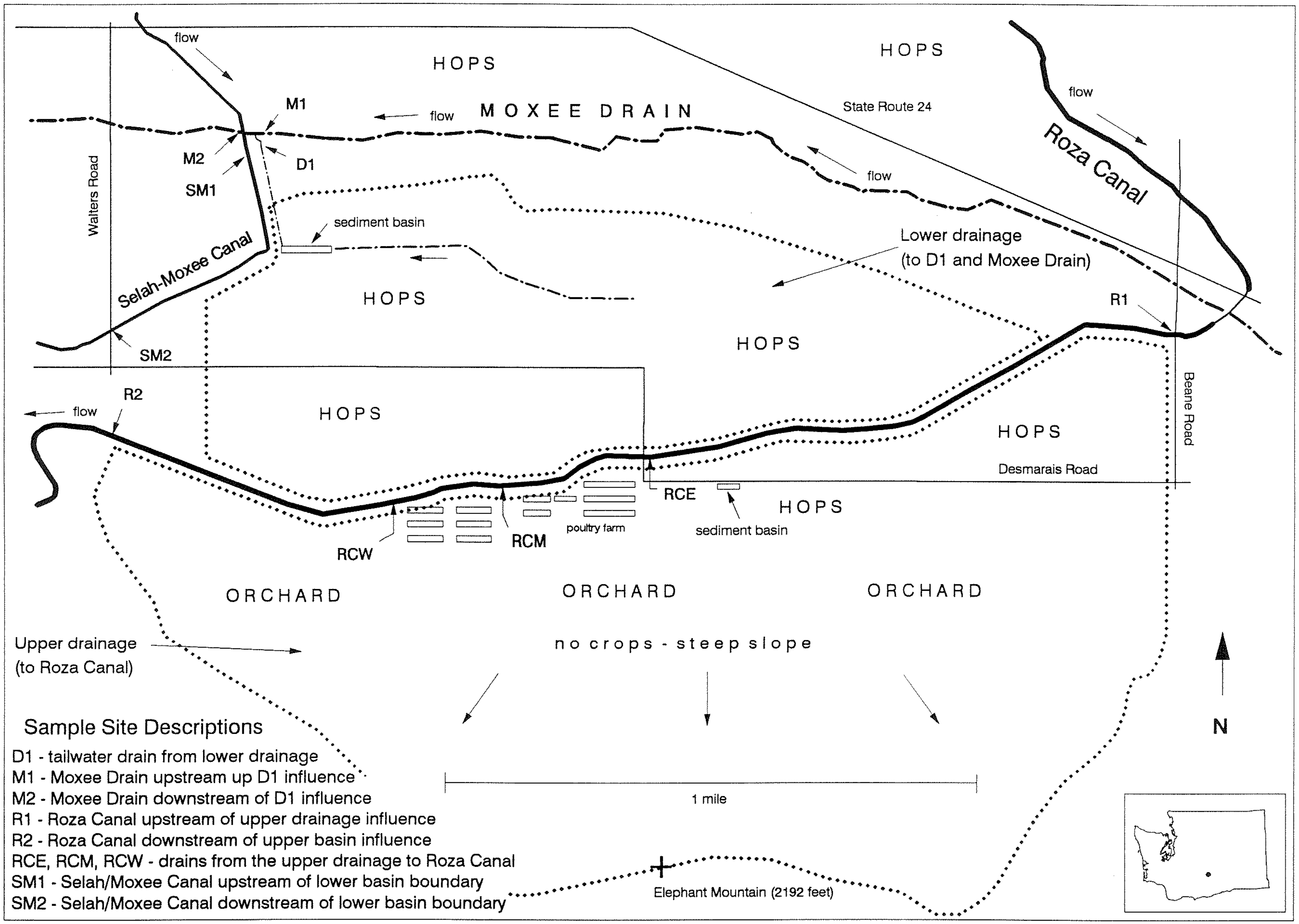


Figure 1. Study Area and Sample Site Location.

Sample sites (Figure 1) were initially selected to allow for two study designs: "upstream-downstream" pairs M1/M2, R1/R2, SM1/SM2; and "before-after" single stations D1, Roza Canal drains, M1, R1, and SM1. Tailwater drain D1 data were used to assess water quality from the lower drainage hops fields. Site D1 is the outlet of a 16" steel pipe which runs approximately 250 yards underground from an inlet structure in the lower drainage to the Moxee Drain. The Moxee Drain sites were chosen to provide data on the impacts of tailwater drain D1 on the Moxee Drain, as well as have one of them serve as a reference site (M1). Site M2 turned out to be poorly mixed because of low velocities and pooling due to a channel restriction designed for an irrigation withdrawal. The Roza Canal stations were sampled to provide data about the influence of tailwater drains from upper basin irrigation practices. Several tailwater drains to the Roza Canal were sampled when they were flowing in order to characterize TSS, turbidity, and nutrient concentrations. These concrete or PVC drains range in diameter from about 4 to 10 inches. Additional drains could not be sampled due to lack of access. The Selah/Moxee Canal stations were abandoned after the first period sampling in 1991 because minimal information would be gained from a single tailwater drain discharging to this canal.

METHODS

General Chemistry

Table 1 lists project water quality parameters, field instrumentation, analytical methods, and lower reporting limits for analyses. Samples were collected for laboratory analysis of TSS, nephelometric turbidity, ammonia, nitrate-nitrite, and total phosphorus. Field determinations were made for temperature, pH, conductivity, absorbtometric turbidity, and flow. Settleable solids using the Imhoff cone test were determined for the Moxee Drain and D1 stations. All water quality samples were subsurface grab samples (4-16 inches depth) collected from the central portion of the stream. Roza Canal water was sampled using a beaker attached to a pole: site R1 samples were obtained from the bridge whereas station R2 samples were collected from the right bank of the canal. All samples were collected in approved sample containers, cooled to 4°C, and transported within 24 hours to Ecology's Manchester Environmental Laboratory by courier.

Settleable solids were determined by averaging the 15 minute settling time results from three Imhoff cone samples. In the field, readings less than 0.05 mL/L were recorded as "trace." For data analyses, "trace" values were set to 0.01 mL/L. A value of 0.01 mL/L was also assigned when the Imhoff test was not performed because visible solids were lacking at the sample site.

Turbidity results were obtained from different instruments and methods. The Ecology laboratory measured turbidity with the EPA approved nephelometric method, which expresses turbidity in Nephelometric Turbidity Units (NTU). In the field, turbidity was measured with a HACH model "dr-el/1" portable environmental laboratory. This instrument, manufactured in the early 1970's, uses the absorbtometric method and expresses turbidity in Formazin Turbidity Units

TABLE 1. PARAMETERS, METHODS and DATA QUALITY EXPECTATIONS for MOXEE BMP DEMONSTRATION PROJECT (1)

Parameter	Method Reference	Lower Reporting Limit	Field Instrument Used
Turbidity (nephelometric)	EPA 180.1	1 NTU	lab
Turbidity (absorptometric)	HACH Owners Manual	2 FTU	HACH "dr-el/1" (1970s model)
TSS	SM-17 2540-C (EPA 160.2)	1 mg/L	lab
Settleable Solids (volumetric)	SM-17 2540-F (modified - settling times variable)	0.05 mL/L	Imhoff cones
NH3-N	EPA 350.1	0.01 mg/L	lab
NO3+NO2-N	EPA 353.2	0.01 mg/L	lab
Total Phosphorus	SM-17 4500-P F	0.01 mg/L	lab
pH	EPA 150.1	0.1 SU	Beckman model Orion model 250A
Conductivity	EPA 120.1 SM-17 2510-B	1 umho/cm @ 25 C	Beckman RB5
Temperature	SM-17 2550-B	0.5 C	Mercury thermometer Bi-metal thermometer
Flow	PSP-Freshwaters bucket-stopwatch	0.01 cfs 0.0001 cfs	Marsh-McBirney 201D top-set wading rod 5 and 20 gallon bucket
TOC	EPA 415 SM-17 5310 PSP SM 209F	1 mg/Kg	lab
Percent Solids	PSP SM 505B	0.1 %	lab
Grain Size	PSP-Sediments	1->62.5 um	lab
Organochlorine pesticides	EPA 8080 EPA 1618 EPA SW-846	variable variable variable	lab
Organophosphorus pesticides	EPA 1618 EPA SW-846 8140 (modified) EPA SW-846 (other)	variable variable variable	lab
Chlorophenoxy herbicides	EPA 515.1 EPA SW-846 8150 (modified)	variable variable	lab

EPA - EPA, 1983.
SM-17 - APHA, 1989.
PSP - PSEP, 1990.
(1) - adapted from Ecology (1991a and 1991b)

(FTU). The definition, criteria and instrument standards for turbidity measurement have changed since the early 1970's, and interestingly, differences of opinion remain over the measurement of turbidity because of difficulty in obtaining good accuracy and precision among different labs and instruments. For this study, the nephelometric results should be reasonably comparable with results from other instruments that meet EPA design and performance criteria for EPA method 180.1. However, the absorbtometric results are comparable only with results obtained from the specific instrument used in this study. Consequently, the nephelometric and absorbtometric turbidity results are not comparable to one another, even though FTU and NTU are sometimes considered equivalent.

Pesticides

Pesticides of interest included chlorinated and organophosphorus pesticides, as well as chlorophenoxy herbicides. Table 1 lists methods used in pesticide analyses. Pesticide samples were collected from several matrices associated with tailwater D1: whole water; 6-hour settleable sediment from whole water; and sediment basin sediment. Six-hour settleable sediment from tailwater at D1 was collected in 1991 only; 1992 samples were not collected because of reduced solids concentrations in the tailwater. However, whole water from D1 and settling basin sediment were sampled for pesticides during 1992. The various matrices sampled and methods used in laboratory analyses serve only to characterize pesticides; evaluation of changes in pesticide levels from 1991 to 1992 is not possible. Pesticide sample collection proceeded as follows:

- Settleable sediment samples for pesticides were collected in June and July 1991 by filling six 5-gallon stainless steel buckets from D1, and allowing sediment to settle out for a period of six hours. The water was decanted and the sediment transferred to an 8-ounce glass container using a teflon-coated stainless steel spatula. The sample was preserved and transported with other samples.

- A whole water composite sample from tailwater drain D1 was collected in June 1992. Samples were collected in 1-gallon glass containers. Half of this sample was collected in the afternoon, the other half collected the following morning.

- Sediment from the outlet end of the sediment basin (the source of tailwater drain D1) was collected in July and August 1992 with a stainless steel grab sampler. The sampler was lowered into the basin about two feet away from the concrete outlet standpipe. Water depth was less than two feet at this point. The top 2-centimeters of sediment were removed with a stainless steel spoon and transferred to an 8-ounce glass container.

Tools used for sampling (e.g. grab sampler, buckets, spatulas, spoons) were specially cleaned in the following sequence: Liquinox® soap and water wash; tap water rinse; pesticide grade methylene chloride rinse; pesticide grade acetone rinse; air dry; and covered with foil until used. Glass containers specially cleaned for trace organics analysis (I-Chem 300 Series) were used for water and sediment samples.

Flow Determination

Flow was determined for sites D1, M1, and R1 using various methods. D1 flow was determined using the velocity cross-sectional area and the bucket-stopwatch method. The bucket-stopwatch method was more appropriate for lower flows than was the velocity cross-sectional method. Data from both methods were used to develop a rating curve from which values of flow were used in data tabulation and analysis.

Flow at M1 was determined using the velocity cross-sectional area method. Flow and pollutant loads were determined using measured flows as well as estimated flows from a rating table. Sedimentation and channel restrictions downstream of M1 (and M2) made flow-stream height relationship at M1 unreliable for the entire study period. Flow at M2 was determined by summing M1 and D1 flows.

Flow at R1 was measured on April 15, 1991, and a rating table developed by using a fitted Manning equation (Grant, 1989). Values from this table were used to estimate R1 flow throughout the study period. Roza Canal tailwater drain flows were measured using the bucket-stopwatch method.

BMP Implementation and Irrigation Water Use

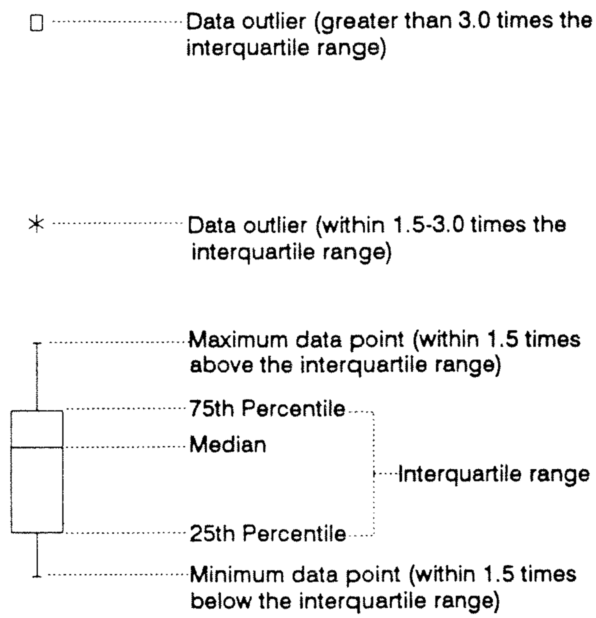
NYCD staff collected information on BMPs that were implemented during the project. This information included the specific BMP practice, location and number of acres served by each BMP, and the BMP start and completion date. More detailed information is presented in Part 1 of NYCD (1993a).

Irrigation water deliveries in the study area were determined using data provided by the Roza Irrigation District and NYCD. These data, used to help interpret water quality results, consisted of daily flows for about 14 delivery points serving specific parcels within the study area. Where parcels straddle the D1 watershed boundary, irrigation deliveries were estimated by using a percentage of parcel acreage laying within the D1 drainage. Some producers in the study area supplement their irrigation water delivery by pumping water from wells or other sources; this supplemental irrigation water was quantified by NYCD as part of determining IWM cost-share eligibility.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

General Chemistry

The QA/QC program for general chemistry parameters included written field procedures (site and instrument specific), instrument calibration and check standards, field replicates, and lab replicates. General chemistry field replicate data are included with all general chemistry data in Appendix A. Overall precision was determined by using the Relative Percent Difference (RPD) of replicate pairs. The RPD is the difference between the two sample results divided by their mean, expressed as a percent. Results are presented in Figure 2 using boxplots.



Box Plot Example

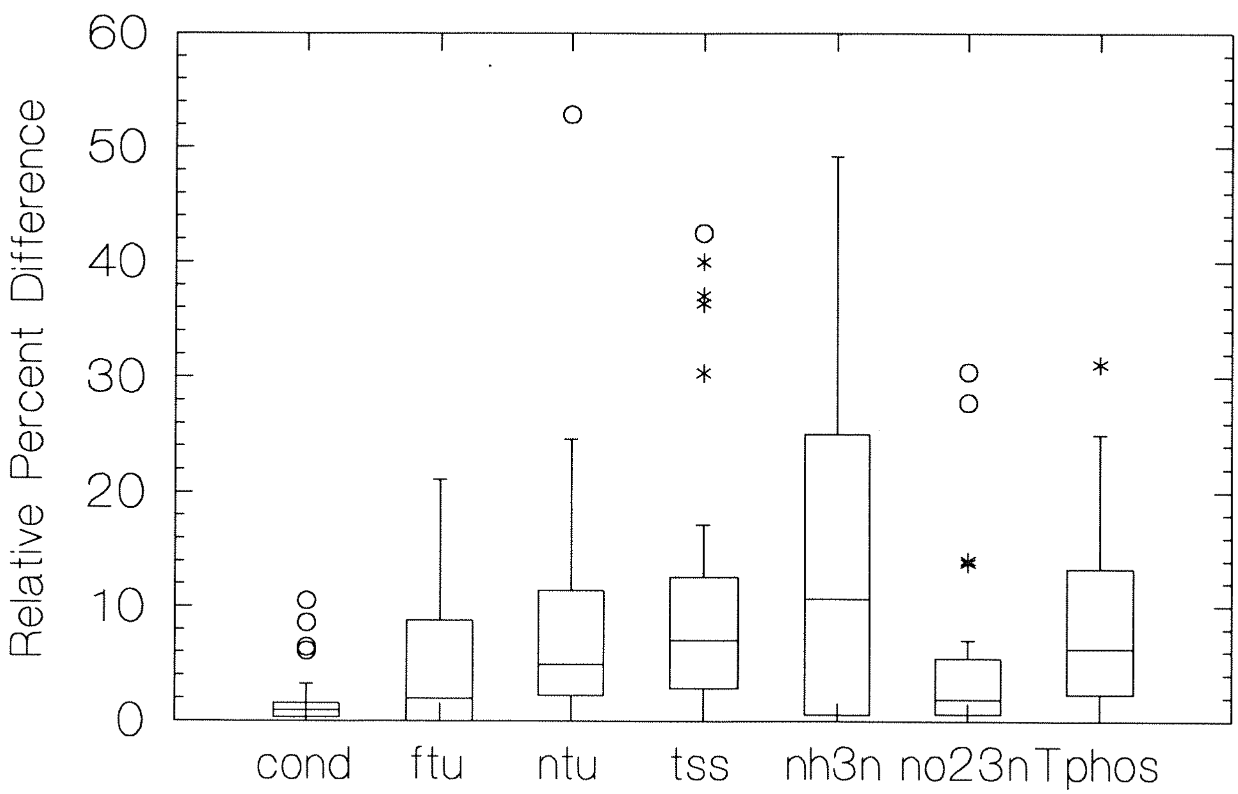


Figure 2. Duplicate Sample Precision.

Precision for general chemistry parameters was deemed acceptable for this study; most RPDs were less than 20%. The high RPDs for phosphorus were generally due to analytical interference caused by high TSS values. High RPDs for nephelometric turbidity and TSS were usually associated with low values or a poorly mixed site (M2). High RPDs for nitrogen compounds were generally associated with values near the detection limit. Results from replicate pairs were averaged for use in data analyses. General chemistry data qualified by the lab were considered acceptable for use in data analyses. Laboratory QA review for total organic carbon, grain size, and percent solids indicated these data were also acceptable for use. Where parameters were undetected, the detection limit was used in data analyses.

Pesticides

All pesticide data, including QA/QC, are presented in Appendix B. Different samples had varying levels of QA/QC associated with them due to sample matrix and quantity available for analyses. Varying detection limits were attained over the range of samples. All analyses were performed satisfactorily except as noted in the following laboratory QA reviews:

- Sample number 248556 collected on June 5, 1991 (settled sediment from D1): Chlorinated and Organophosphorus Pesticides - This sample was extracted six days beyond the SW-846 recommended holding time of 20 days. In this case, the exceedance probably had no measurable effect on results; therefore no qualifiers were added to these data. For organophosphorus pesticides, the matrix spike and matrix spike duplicate (MS/MSD) recoveries and precision were good, suggesting that data quality may not be compromised because of the lack of surrogate recovery data.

- Sample number 328474 collected on July 31, 1991 (settled sediment from D1): Chlorinated Pesticides - MS/MSD recoveries exceeded limits for 4,4'-DDT, this was likely due to the ambient amount of this compound being 10 times greater than that added during the spike. Dilution for the MS/MSD was performed to quantify DDT and DDE within the calibration range. MS/MSDs were run three times; either one can be used. Organophosphorus Pesticides - Surrogate recoveries were low and beyond advisory QC limits. Re-extraction was not possible due to insufficient sample. All non-detected results were qualified with a "UJ." Diazinon was detected at 0.36 ppb and qualified with a "J."

- Sample number 248861 collected on June 8 and 9, 1992 (whole water from D1): Organophosphorus Pesticides - The surrogate recoveries are reasonable and data quality sufficient for use. Herbicides - Results were qualified with a "J" due to low surrogate recovery.

- Sample number 328763 collected on August 4, 1992 (sediment basin sediment): Herbicides - The soil blank exceeded extract holding time, thus a "J" qualifier was added to the data.

RESULTS AND DISCUSSION

BMP Implementation

The level of BMP implementation varied through time and by specific practice. Generally, structural practices such as sediment basin construction and irrigation retrofits were completed by mid-June of 1992, while managerial practices such as furrow mulching and IWM occurred throughout the 1992 season. A thorough accounting of project BMPs is provided in Part 1 of NYCD (1993a). The following summarizes specific practices implemented in drainage area D1 only:

> A sediment settling basin was installed in February 1992 and served the entire D1 drainage (about 370 acres in crops). Irrigation system retrofits (valves, piping, sprinkler heads, etc.) were installed throughout the 1992 irrigation season and served about 256 acres. Irrigation water management (specific to timing and application of water) was implemented on about 253 acres. Reduced tillage served about 30 acres during the 1992 season. Furrow mulching was implemented 1 to 3 times on about 253 acres throughout the 1992 season. The number of irrigation cycles per growing season ranges from 4 to 8 or more and is dependent upon individual growers' practices. Straw-mulched irrigation furrows serve a number of irrigation cycles before furrows are disced and mulched again.

Irrigation Water Use

Figure 3 depicts the sum of daily irrigation water delivery from the Roza Canal to users in the D1 drainage during each irrigation season. The 1992 deliveries are more even and of lesser quantity than 1991, probably due to IWM. Crop-water need influences the timing, rate, and quantity of irrigation water applied to any crop, but is an unlikely reason for differences seen in Figure 3 because crop-water needs for hops in 1992 were about 20% greater than for 1991 (NYCD, 1993b). An additional factor may have been reduced irrigation water supply.

A reduced water supply in 1992 resulted from lower than normal snowpack, spring rains, and runoff (Bureau of Reclamation [BOR], 1992). On June 5, 1992, BOR announced that certain Yakima Project users (Roza Irrigation District and others) were prorationed to 58% of their normal water allotments for the water block period from May 16 to the end of the irrigation season. This reduced allotment probably served as an added incentive for project area irrigators to more carefully implement IWM. Part of the 42% reduction in allotment was met by producers not irrigating from mid-September to mid-October 1992. This post-harvest irrigation in hops fields has traditionally been used to raise soil moisture for winter and the following irrigation season rather than meet crop-water need (which is virtually zero). The remainder of the reduction was probably met through reduced water use during the growing season. Supplemental irrigation water (from wells or other sources) accounted for less than 4% of total water applied to the D1 drainage.

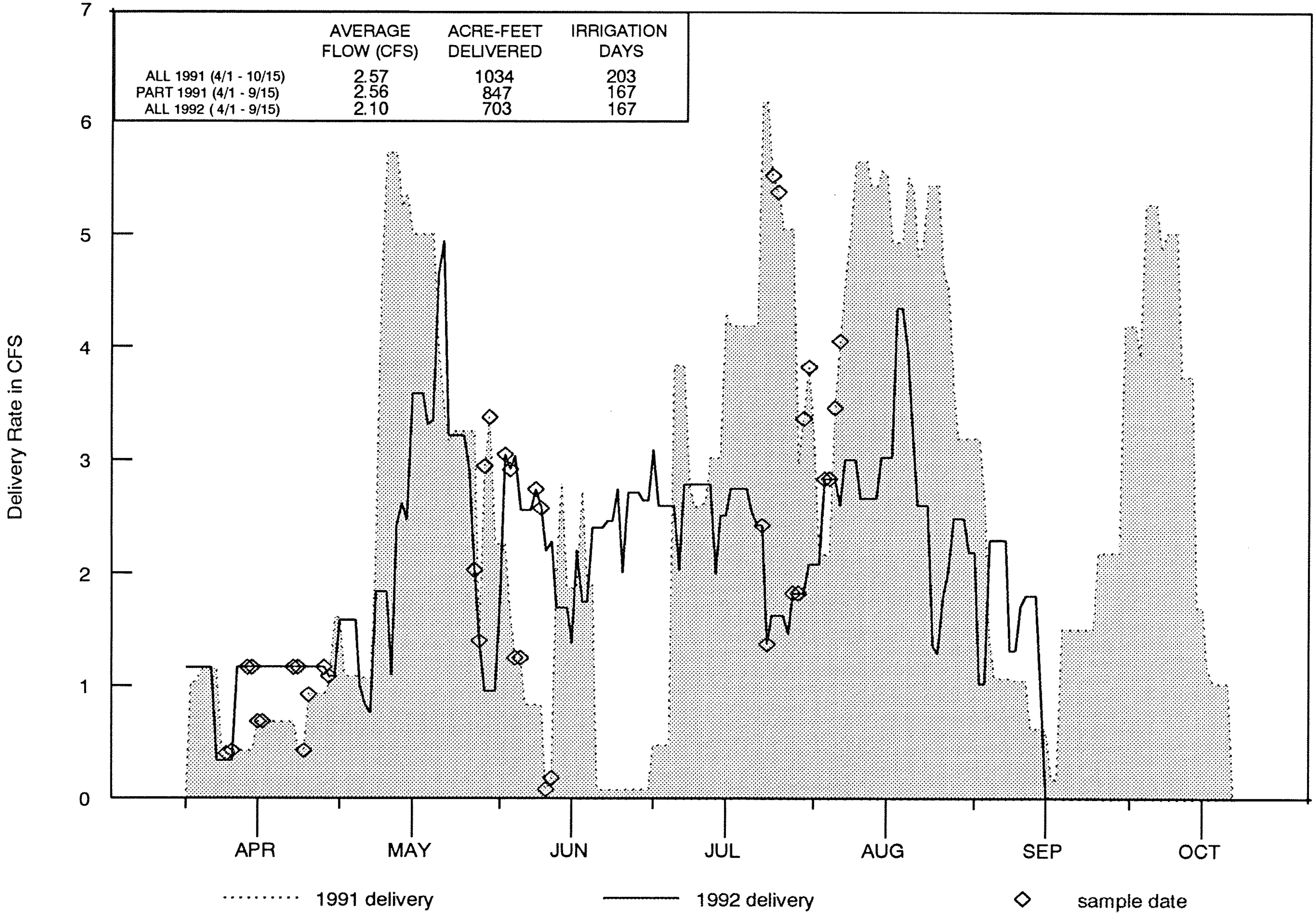


Figure 3. Irrigation Delivery in Sub-basin D1.

General Chemistry

Field and laboratory data for conventional parameters are presented in Appendix A. Appendix C graphically summarizes these data using boxplots. Data are grouped by parameter, station, and sampling period. Combined data from all periods (early - "E", middle - "M", and late - "L" irrigation season) within each year are denoted by an "all" designation. The off season period is designated by "offseason." These graphical summaries reveal general trends in water quality throughout each irrigation season, between years for each station, and between stations for the Roza Canal and Moxee Drain. Appendix C plots helped determine approaches in data analyses but are not described further in this report.

Approach to Analysis

The objective of evaluating BMP effectiveness on irrigation tailwater and receiving waters requires several determinations:

a) Detect and quantify changes in water quality during the "before-after" BMP time period and between the "upstream-downstream" locations,

b) determine and quantify changes in the levels of NPS controls (BMPs) during the study period, and

c) find evidence that the changes in water quality were a direct result of the changes in NPS control levels and not a result due to other variables.

The approach to data evaluation is presented below. Changes in NPS controls are quantified in Part 1 of NYCD (1993a) and summarized for drainage area D1 above. The BMP-water quality connection will be discussed following presentation of the water quality changes.

Water quality results were examined for all sites to guide further data evaluation. Data sets that would be most appropriate to use for evaluating water quality and BMP associations were examined based on land use, crop cultural practices, BMP implementation, irrigation practices, and tailwater flow. Comparisons of individual sampling periods were not done due to the high variability associated with small sample sizes. D1 data were pooled and examined by year, sample period, flow, and irrigation delivery to determine which data set best represented the two irrigation seasons. The potential effect that base flow at D1 (about 0.45 cubic feet per second [cfs]) might have on water quality comparisons was also considered. Pooled data from the middle and late sample periods were chosen to evaluate 1991 to 1992 water quality. The early period data were excluded because:

a) early sample period irrigation and cultural practices were highly variable,

b) implementation of BMPs was low during the early 1992 period with only the sediment basin having been installed, and

c) furrow mulching and much of the irrigation retrofits began after the early part of the 1992 season.

Notched boxplots were used to determine significant differences between data sets. This non-parametric statistical technique provides a simple graphical summary of the data and depicts a 95% confidence interval about the median. These plots were produced for all sites using SYSTAT software (Wilkinson, 1990); however, only plots for sites D1 and M1 are presented here. Figure 4 explains how notched boxplots characterize data and how the notches, or confidence intervals, are used to compare differences between data sets.

Water quality results from D1, M1, and M2 indicate differences for some variables between years at each site. Differences between M1 and M2 (upstream-downstream) were not detected for either year.

Tailwater Drain D1

Tailwater Drain D1 - Median differences between years:

> Figure 5 boxplots show significant reductions from 1991 to 1992 in TSS (86%), TSS load (90%), Imhoff SS (99%), nephelometric turbidity (63%), absorbtometric turbidity (75%), ammonia (56%), and ammonia load (60%). A slight increase, although not statistically significant, in nitrate/nitrite concentration and conductivity between 1991 and 1992 may have been due to a larger proportion of the 1992 flow being made up of ground water base flow. Off-season nitrate/nitrite concentrations are high (around 7 mg/L - Appendix C-3) and are typical of levels found in lower Moxee Valley ground water (Larson, 1993). An 18% reduction in flow was not statistically significant.

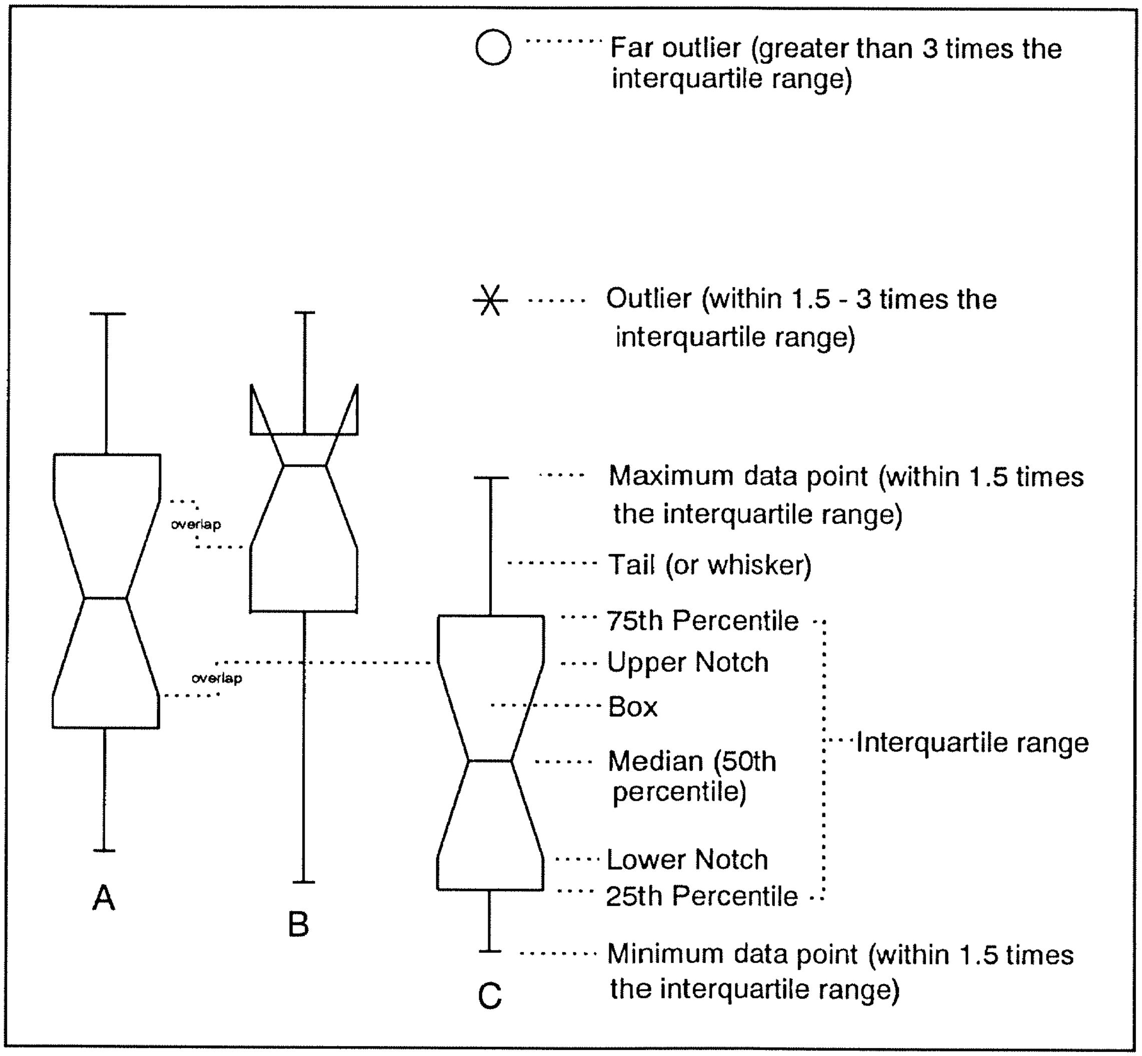
Moxee Drain

Moxee Drain - M1 median differences between years:

> Significant reductions at M1 from 1991 to 1992 occurred for flow (28%), Imhoff SS (93%), nephelometric turbidity (52%), and absorbtometric turbidity (48%). Parameter concentrations and loads from 1992 were generally lower and had smaller ranges than 1991 values, except for conductivity and nitrate/nitrite. A significant increase occurred in conductivity (10%), suggesting that a larger proportion of 1992 flows were made up of ground water than were the 1991 flows, as was for D1 (Appendix C-7). Similarly, elevated nitrate/nitrite is likely due, in part, to base flow influence (Appendix C-8).

Moxee Drain - M2 median differences between years:

> Significant reductions at M2 from 1991 to 1992 occurred for flow (25%), TSS load (77%), Imhoff SS (95%), and absorbtometric turbidity (58%). Significant increases at M2 from 1991 to 1992 occurred for conductivity (12%) and nitrate/nitrite (37%).



Interpretation: Boxplots graphically display the distribution and characteristics of sample data. 50% of the sample data lie within the box. The rest of the data, except outliers, lie within the upper and lower tails. Symmetrical plots (like A) suggest that sample data are normally distributed. Asymmetrical plots (like B - long tail and 75th quartile close to median) may indicate a skewed distribution. Notched boxplots are useful for finding differences between two groups. The upper and lower notches designate the 95% Confidence Interval (CI) around the median. If the notches around two boxplot medians do not overlap, as in B and C above, the two population medians are significantly different at approximately the 95% confidence level (Wilkinson, 1990). In the figure above, the medians of populations A and B, and A and C, are not different, even though their sample medians are different. In plot B, the upper confidence limit extends beyond the 75th percentile, making the upper part of the plot appear as if it has folded over. The CI is dependent upon sample size and the variability of the data: a small sample size or highly variable data tend to result in a larger CI.

Figure 4. Boxplot Example.

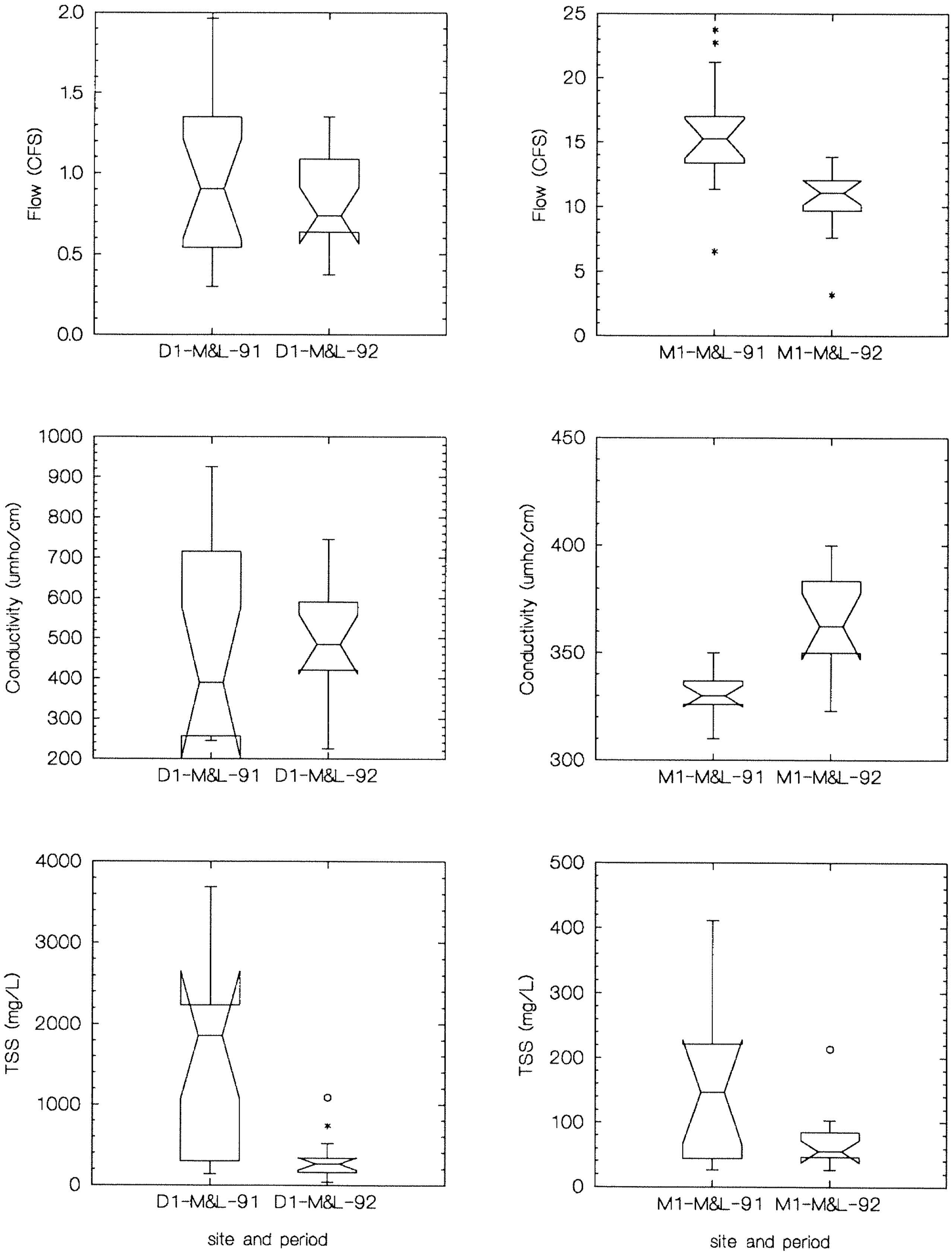


Figure 5. Sample Result Distributions for Sites D1 and M1.

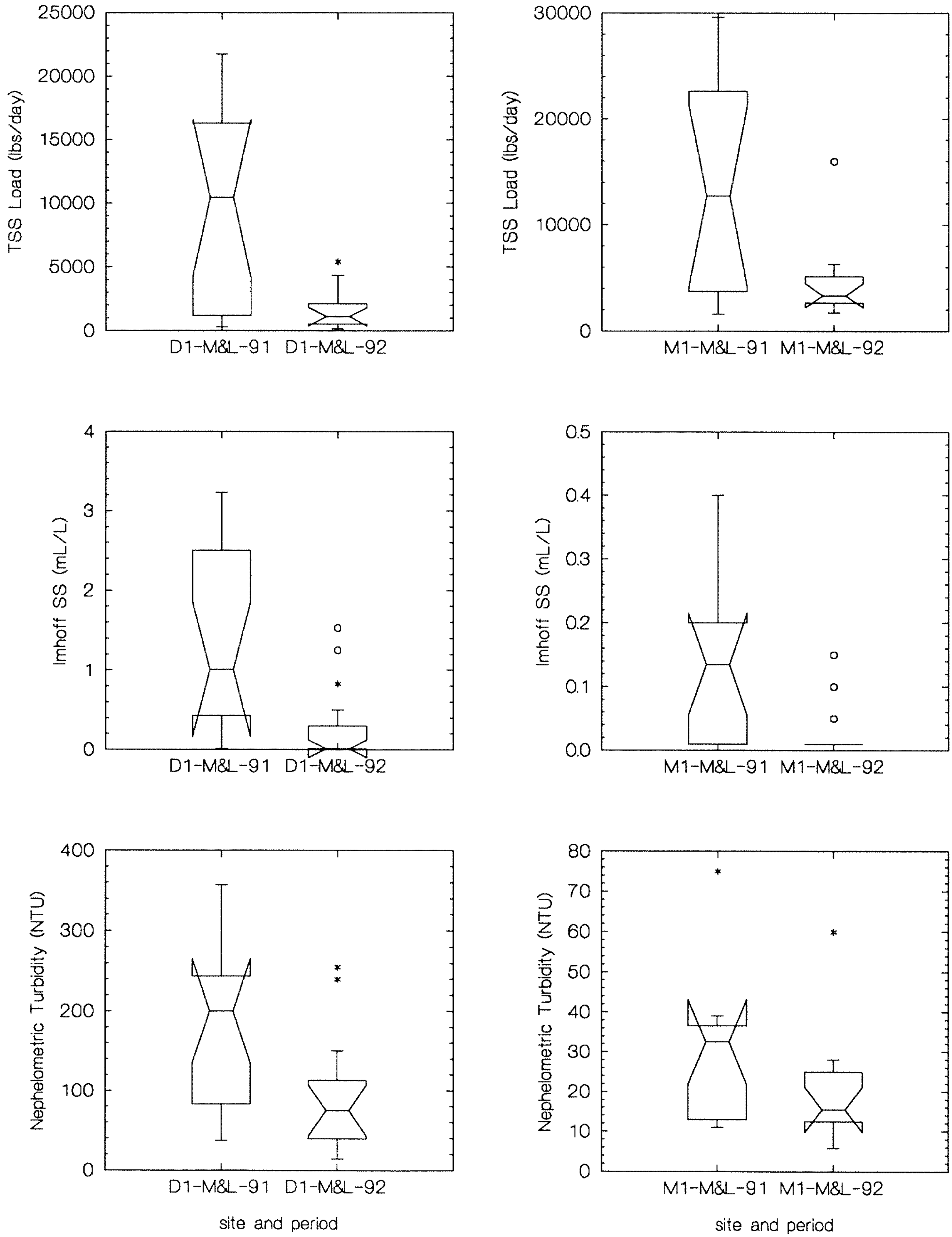


Figure 5. (continued)

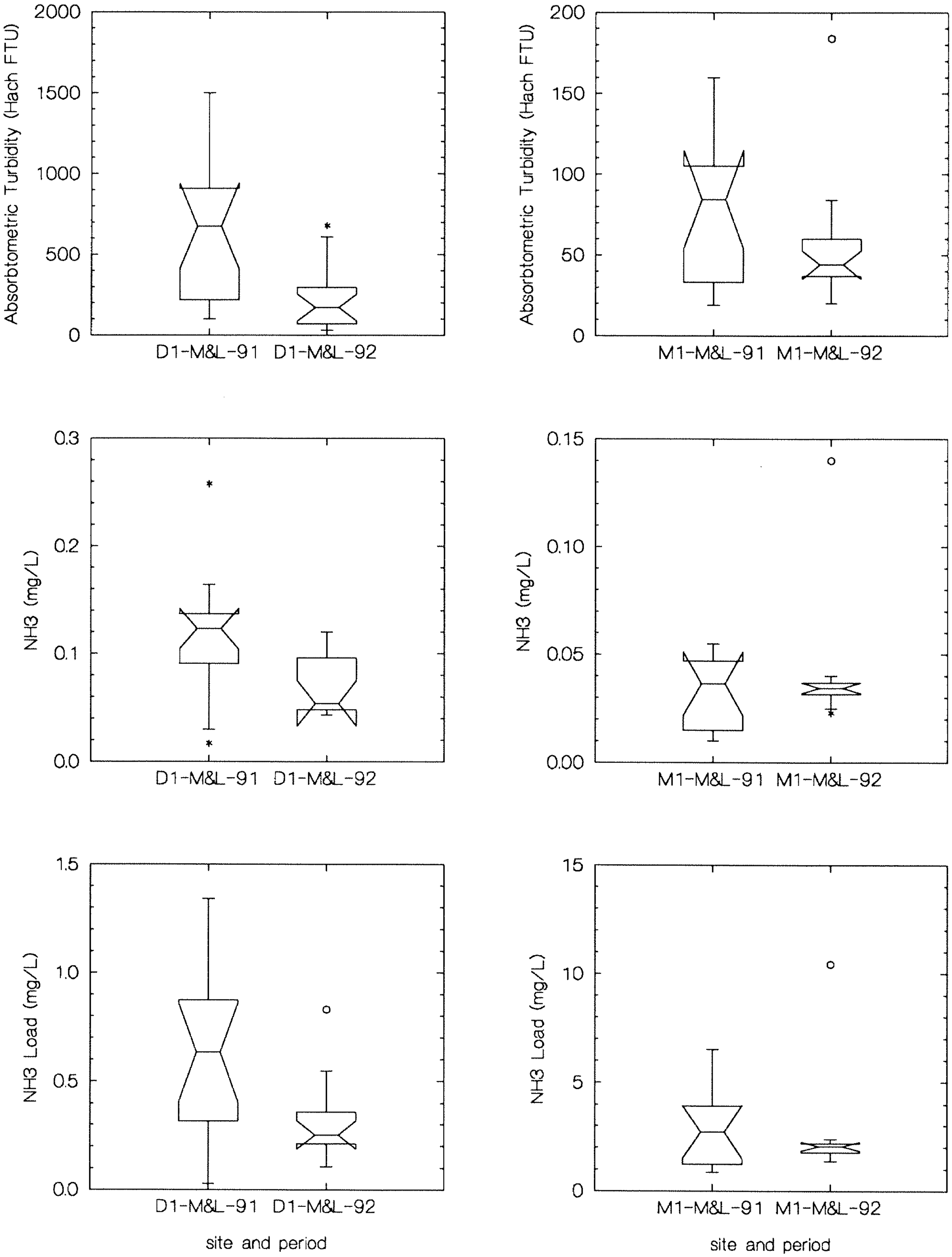


Figure 5. (continued)

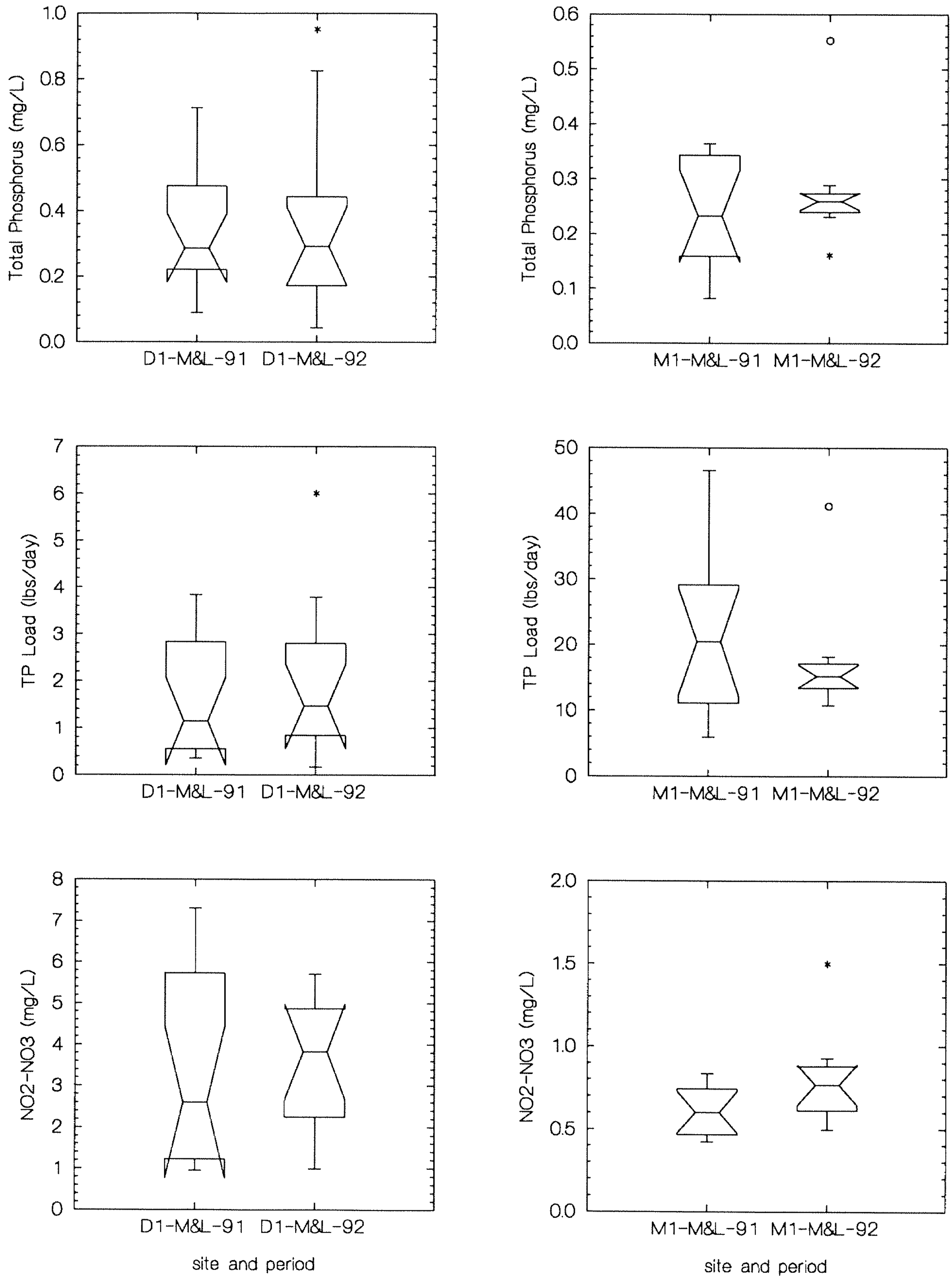


Figure 5. (continued)

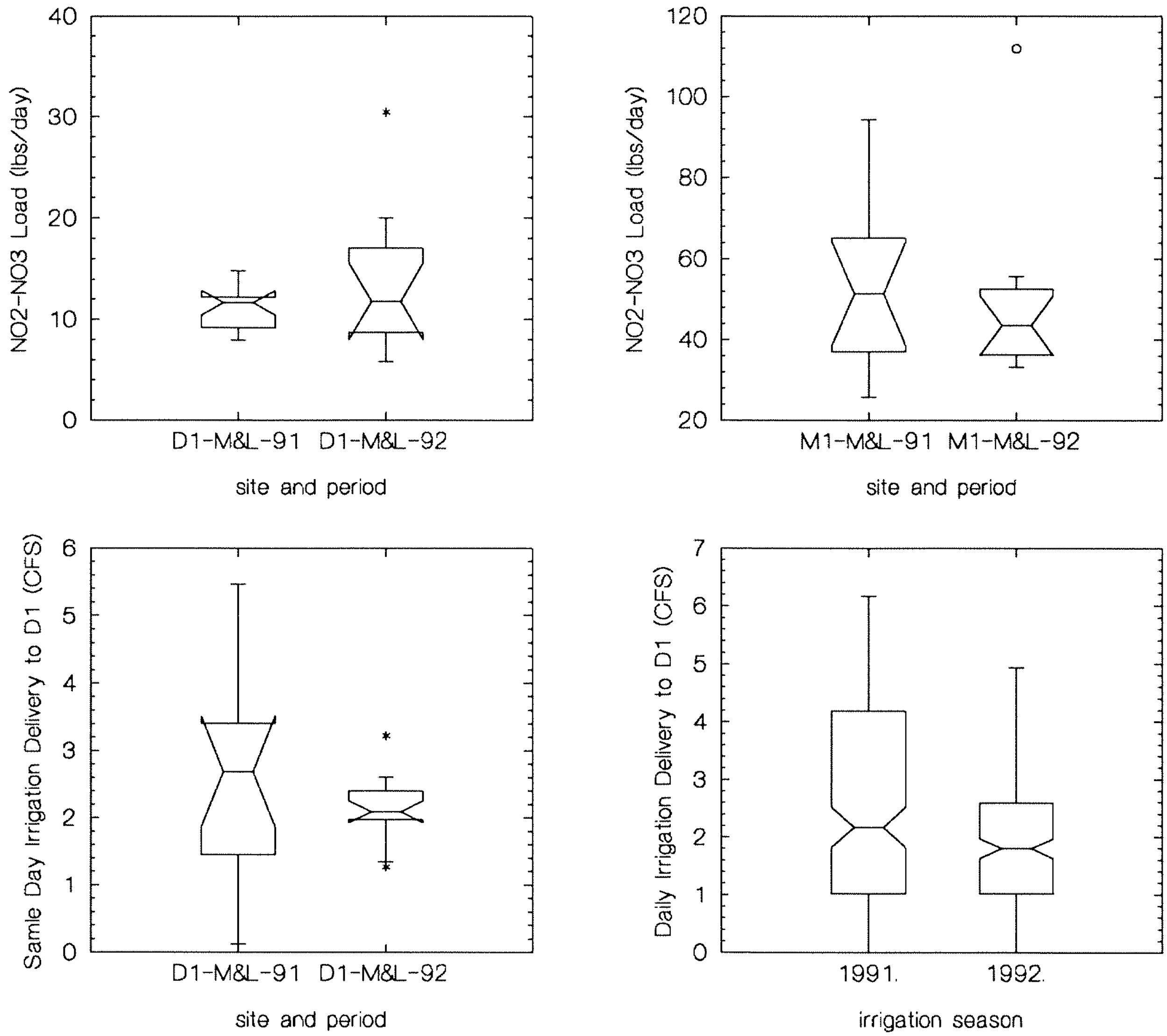


Figure 5. (continued)

Moxee Drain - M1 and M2 median differences within each year:

> No significant differences for any parameter existed between M1 and M2 in 1991 or in 1992. However, ammonia loading showed a significant increase (from M1 to M2) in 1992, despite median reductions in loads from M1 and D1; concentrations were relatively low and near detection limits as well. While no significant differences between M1 and M2 for either year were detected, parameter concentrations at M2 were generally higher than they were at M1 (for both years), suggesting the impacts of D1 on the Moxee Drain. This "upstream/downstream" study design to evaluate the impacts of irrigation tailwater on a receiving water proved to be insensitive due to high variability of water quality in both the receiving water and input water.

<u>Roza Canal</u>

Roza Canal - R1 and R2 median differences within each year:

> No significant differences in water quality between R1 and R2 were detected for either year. An apparent 20% increase (from R1 to R2) in absorbtometric turbidity in 1992 is near the limit of instrument accuracy and may not be indicative of real changes in water quality (median values from about 12 to 10 FTU). The "upstream/downstream" strategy used to evaluate the impacts of irrigation tailwaters on this receiving water proved to be insensitive due to the unmeasurable effects of project-area tailwater drains on the Roza Canal.

Roza Canal - R1 median differences between years:

> Significant reductions at R1 from 1991 to 1992 were evident for flow (34%), nephelometric turbidity (39%), and nitrate/nitrite (39%). These differences may be related to lower flows within the canal, as well as reduced input from upstream tailwater discharges. A 39% apparent increase in ammonia from 1991 to 1992 may not have been a real change but rather associated with analytical uncertainty of the low concentrations of ammonia found; many values were at or near the detection limit.

Roza Canal - R2 median differences between years:

> Significant reductions at station R2 between 1991 and 1992 were similar to those seen at R1: nephelometric turbidity (37%) and nitrate/nitrite (86%). Significantly higher values of ammonia were present in 1992 than in 1991. Again, ammonia differences are attributed to uncertainty associated with the low concentrations of ammonia found.

Roza Canal water is a significant source of water for tailwater drain D1 during the irrigation season. Parameter concentrations in Roza Canal water are generally one to two orders of magnitude lower than those of levels found in D1. Hence, differences in Roza Canal water quality probably had no measurable effect on the water quality of D1 between the years.

Roza Canal Drains

Drain RCE was the only drain sampled during both years. RCE water drains a sediment basin that collects tailwater from about 77 acres of furrow irrigated hops. The sediment basin for this tailwater drain has been in place for several years. Sample size and sample periods were different for each year at this station, so comparisons are limited in value and serve to illustrate the importance of sampling during similar conditions in before/after studies. Significant reductions from 1991 to 1992 were detected for TSS (73%), nephelometric turbidity (69%), and nitrate/nitrite (82%). Significant increases occurred for flow (236%) and total phosphorus loading (250%).

Drain RCM conveys runoff from the poultry operation and orchards. This drain was flowing only during the 1991 sample periods. The poultry facility appeared to be in full operation in 1991 and barns were frequently observed to be cooled by water sprinkled on their roofs. Some of this runoff appeared to make its way to the Roza Canal via drain RCM. The sources of high nutrient concentrations in this drain (Appendix C-15) may be the poultry operation and orchard fertilizers.

Drain RCW drains an orchard area just west of the poultry barns. The sources of elevated nitrate/nitrite levels (Appendix C-15) in 1991 runoff from this area may be the poultry operation and fertilizers used in the orchards. No flows were observed in 1992 from this 6-inch pipe.

In summary, these Roza Canal drains provided little information on water quality changes between years because of intermittent or non-existent flows during sample periods. The Roza Canal was least sensitive to water quality changes due to project area activities because of the canal's large flow and the relatively small impact of drains contributing to it. This study found that the combined flows for these drains (when flowing) accounted for approximately less than 1% of the flow in the canal and generally less than 0.5 - 2.0% of the nutrient or solids load in the canal. Sampling and analytical uncertainty also contributed to low sensitivity in detecting water quality changes in the Roza Canal between years, as well as within each year.

Tailwater drain D1 and the Moxee Drain sites offered the best opportunity to detect changes in water quality and associate them to changes in BMPs. Both D1 and the Moxee Drain are heavily impacted by irrigation return flows from furrow-irrigated lands, thus the effects of pollution control practices might best be detected at those locations.

The Water Quality - BMP Connection

Changes in weather and water availability from year to year confounded evaluation of BMP effectiveness, however, evidence exists that BMPs contributed to improved water quality in 1992. Water quality improvements from 1991 to 1992 were seen at sites D1, M1, and M2 for various parameters. Table 2 summarizes median values and the percent change of parameters for each of these sites. Note that a large water quality change between years (greater than 50%) is generally required before a change becomes statistically significant at the 95% confidence

TABLE 2. Changes in Median Values for Middle and Late Season Pooled Data at Sites D1, M1, and M2 Between 1991 and 1992.

parameter	D1 1991 median	D1 1992 median	D1 percent change		M1 1991 median	M1 1992 median	M1 percent change		M2 1991 median	M2 1992 median	M2 percent change	
Flow (cfs)	0.90	0.74	-18 %	NS	15.30	11.00	**-28** %		15.99	12.01	**-25** %	
Conductivity (umho/cm)	390	485	24 %	NS	330	362	**10** %		332	371	**12** %	
TSS (mg/L)	1860	265	**-86** %		147	55	-63 %	NS	192	72	-63 %	NS
TSS Load (lbs/day)	10422	1088	**-90** %		12707	3342	-74 %	NS	21830	5042	**-77** %	
Imhoff SS (mL/L)	1.01	0.01	**-99** %		0.14	0.01	**-93** %		0.20	0.01	**-95** %	
Turbidity (NTU)	200	75	**-63** %		33	16	**-52** %		40	23	-42 %	NS
Turbidity (FTU)	676	171	**-75** %		85	44	**-48** %		120	51	**-58** %	
NH3 (mg/L)	0.12	0.05	**-56** %		0.04	0.04	-5 %	NS	0.04	0.04	5 %	NS
NH3 Load (lbs/day)	0.63	0.25	**-60** %		2.72	2.06	-24 %	NS	3.65	2.56	-30 %	NS
Total P (mg/L)	0.29	0.29	2 %	NS	0.23	0.26	11 %	NS	0.29	0.27	-7 %	NS
Total P Load (lbs/day)	1.14	1.46	28 %	NS	20.40	15.17	-26 %	NS	24.52	15.41	-37 %	NS
NO2-NO3 (mg/L)	2.60	3.82	47 %	NS	0.60	0.77	27 %	NS	0.69	0.94	**37** %	
NO2/NO3 Load (lbs/day)	11.64	11.78	-1 %	NS	51.37	43.50	15 %	NS	61.26	56.05	9 %	NS

NS = not statistically significant at the 95% confidence level

level. Large changes are needed because of high variability associated with these data. For example, a 63% reduction in median TSS at M1 or M2 was not significant while an 86% reduction at D1 was significant. This is not uncommon since water pollution data are highly variable and subject to various types of uncertainties, including those arising from the dynamics of intensive land use and the interaction of other physical and biological processes (Gilbert, 1987).

Water quality impacts from furrow irrigated lands in this study are mostly caused by irrigation practices. Irrigation practices are in turn affected by weather, crop-water needs, water availability (quantity and rate), and crop culturing practices. The success of before/after BMP study designs are highly dependent upon external variables (e.g. weather, crop-water need, etc.) remaining similar throughout the study period such that their influence is nearly constant from year to year.

Evaluating water quality at a reference site not affected by project BMPs is one way to measure water quality changes due to weather related and other unknown effects. For this study, site M1 was considered a reference site for site D1 because of the following similarities in basin characteristics:

a) Behavior of the flow regime in each is similar. Base flow in each is due to natural inputs, while irrigation return flows dominate the flow regime during the irrigation season. Irrigation season flows at M1 are up to 2- to 8-times that of offseason flows; irrigation season flows at D1 are up to 4 times that of offseason flows.

b) Water quality is highly variable in each basin and appears to be dominated by irrigation return flows.

c) Land use in the D1 drainage consists of 370 acres of mostly furrow-irrigated hops. Land use in the M1 basin is more diversified: range land, hay land, small grains, and hops are present. However, approximately 650 acres of furrow-irrigated hops exist just upstream of M1, adjacent to the Moxee Drain. These furrow-irrigated lands probably dominate the water quality and flow regime at M1. An additional 120 acres of drip-irrigated hops upstream of M1 produce no tailwater and likely had no impact on the quality of surface water. Environmental factors, such as the reduced water allotment and other unknown factors, are assumed to have affected both areas similarly.

d) The levels of BMP implementation were assumed to be different in each basin: the D1 drainage had numerous planned BMPs that treated about 70% of the land within the drainage. The M1 basin had little or no change in the level of BMP implementation between 1991 and 1992, except possibly for necessitated IWM due to reduced water allotments.

Comparing water quality changes at M1 to changes at D1 can help distinguish between the effects of project BMPs in the D1 drainage from the effects of other factors such as reduced water allotments. Water quality changes at M1, and generally throughout the irrigated lands in the Moxee Valley, are most likely caused by irrigation practices, climate, and other growing-season characteristics. The magnitude of between-year change at M1 shows the effects of these variables. Water quality changes at D1 are influenced to a similar degree by these same factors, but also by BMPs implemented during 1992. Therefore, a greater change in water quality at D1 versus the change at M1 would provide evidence that BMPs were effective in improving water quality.

Figure 6 relates the magnitude of water quality changes from 1991 to 1992 among sites D1, M1, and M2. While all of the causes for water quality improvement at M1 cannot be determined, necessitated IWM due to reduced water allotments likely accounts for a large portion of the changes. A greater change in water quality at D1 than at M1 occurred for TSS, TSS load, Imhoff SS, nephelometric turbidity, absorbtometric turbidity, ammonia, and ammonia load. These changes are strong evidence for the positive effects of project BMPs on water quality. While conductivity and nitrate/nitrite increased at D1, these changes were attributed to the greater influence of baseflow and other groundwater related effects in 1992. Changes in total phosphorus were not significant, but an increase from 1991 to 1992 was suggested for total phosphorus loading. This might be due to sediment-bound phosphorus releasing phosphorus to the water column, thus masking any real improvement. King *et al.* (1984) also found that reduced sediment discharge doesn't necessarily accomplish phosphorus reduction.

At site D1, TSS, and Imhoff SS reductions were similar to those attained for irrigation BMPs in Idaho's Rock Creek Rural Clean Water Program project (USDA *et al.*, 1991). During the 10-year Rock Creek study, solids removal efficiencies of sediment basins ranged from 75-95%, while a 40-80% sediment reduction was reported for furrow mulched areas. Similarly, NYCD (1992) reported the following average pollutant reductions for individual mulched furrows: settleable sediment - 79%, TSS - 91%, and nephelometric turbidity - 89%.

At site M1, solids reductions were substantial and probably due to external variables such as careful water management within the M1 basin and possibly reduced resuspension and transport of sediment within the Moxee Drain itself (because of lower flows and water velocities). Flow reductions may be attributed to necessitated IWM (due to reduced irrigation allotments) by irrigators in the M1 basin; water withdrawals from the Moxee Drain itself for supplemental irrigation may also have been a factor.

Pesticides

Pesticides associated with sub-basin D1 water and sediment were characterized and compared to results from other studies. Appendix C contains complete laboratory results, Table 3 presents results from water samples, and Table 4 presents sediment sample results. Evaluation of BMP effectiveness regarding pesticides was not an objective of this study nor is it possible because of the different matrices sampled and the various analytical methods used.

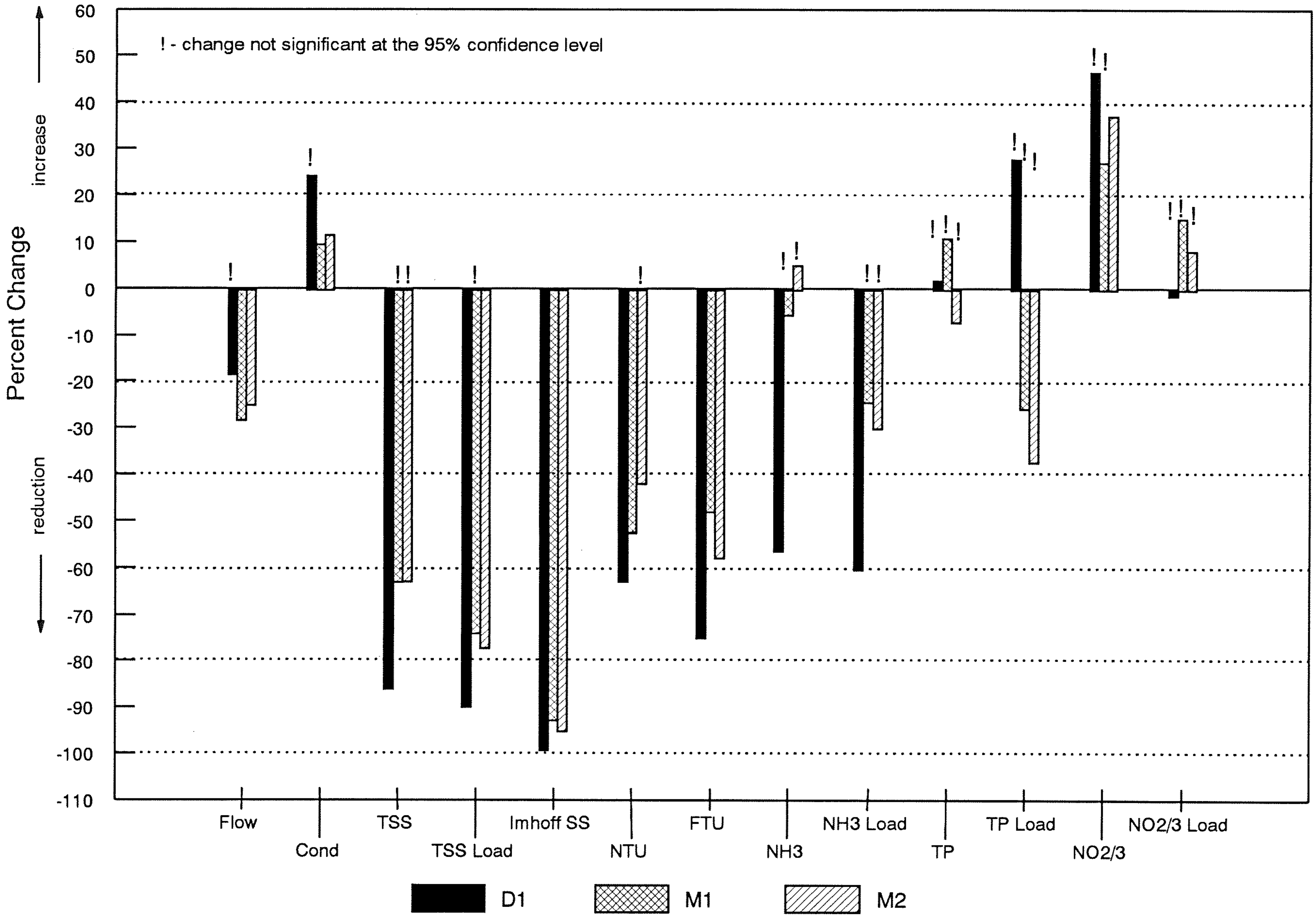


Figure 6. Significant Changes in Water Quality Parameters Between 1991 and 1992.

Table 3. Pesticides Detected in Water and Comparison to Historical Findings and Criteria.

Location:	Tailwater drain D1 near Walters Road	Moxee Drain below Birchfield Road	Moxee Drain at Thorp Road	Moxee Drain at Thorp Road	Moxee Drain at Birchfield Road	WA Water Quality Standards (Ch. 173-201A WAC) (a) Chronic Freshwater	Acute Freshwater
Investigator:	this study (1993)	Davis (1993, in prep)	Rinella, et al (1992)	Rinella, et al (1992)	Johnson, et al (1986)		
Sample Date:	6/8 - 9/92 (whole water)	1992 (whole water)	1988 - 1991 (whole water)	1988 - 1991 (filtered water)	1985 (whole water)		
Lab Log#:	248861						
4,4'-DDE (ug/L)	0.024	0.018 J	0.004 - 0.040	0.0056 .002 - .006 (b)	0.01 - 0.02	0.001	1.1
4,4'-DDD (ug/L)	0.010	0.028 J	0.001U - 0.002	<0.001 - 0.001 (b)	0.01 - 0.02U	0.001	1.1
4,4'-DDT (ug/L)	0.029	0.015 J	0.001U - 0.034		0.01U - 0.04	0.001	1.1
t-DDT (ug/L) (d)	0.063	0.061 J	0.003 - 0.058	0.015 0.002 - 0.011 (b)	0.005U - 0.07		
2,4-D (ug/L)	0.032	0.16	0.001 - 1.900	0.41 <0.010 - 1.3 (b)			
Diazinon (ug/L)	0.161 U	0.07 U	0.001U - 0.630		1.7		
TSS (mg/L)	225	287	47 - 607 252 - 1450 (b)		7 - 500		
TOC (mg/L)	8.6	5.4	4.2 - 10J (c) 4.9 - >8.0 (b)		2.2 - 8.0		

(a) - Same as EPA (1986) Criteria with exception: EPA has no acute criteria for DDT metabolites.
(b) - Samples from Moxee Drain at Birchfield Road.
(c) - Sum of dissolved and suspended matter TOC.
(d) - "Total" DDT; sum of the DDT compounds presented here.

J - The analyte was positively identified. The reported result is an estimate.
U - The analyte was not detected at or above the reported result

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Table 4. Pesticides Detected in Sediment and Comparison to Historical Findings and Criteria.

Location:	Tailwater drain D1 near Walters Road	Tailwater drain D1 near Walters Road	D1 sediment basin near Walters Road	Moxee Drain at and above Birchfield Road	Moxee Drain at Thorp Road	Moxee Drain at Thorp/Birchfield Road	hops/apple soils nr Moxee City	Provincial Sediment Quality Guidelines	
Investigator:	this study (1993)	this study (1993)	this study (1993)	Johnson, et al (1986)	Rinella, et al (1992)	Rinella, et al (1992)	Rinella, et al (1992)	Persaud et al (1992)	
Sample Date:	6/5/91	7/31/91	8/4/92	1985	1988	1988-1991	1989	Lowest	Severe
Sample Type:	settled sediment	settled sediment	basin sediment	streambed sediment	streambed sediment	suspended sediment	soil (a)	Effect	Effect
Lab Log#:	248556	328474	328763						
Units:	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/L	ug/Kg	ug/Kg	
	ug/Kg OC	ug/Kg OC	ug/Kg OC		ug/Kg OC				ug/Kg OC
4,4'-DDE	21	41	16	1.3 - 65	65 - 91	0.071 T	29 - 160 H	5	
	1400	2240	2162	(b)	5909 - 7583	0.001 - 0.006 B	45 - 680 A		19000
4,4'-DDD	4.4	3 U	3.2	0.33 - 22	18 - 23	0.016 T	1.4 - 27 H	8	
	293	164 U	432	(b)	1636 - 1917	0.0001 - 0.001 B	3.5 - 56 A		6000
4,4'-DDT	10	36	12	1.8 - 41	8.5 - 15	0.096 T	22 - 310 H		
	667	1967	1622	(b)	773 - 1250	0.001 - 0.005 B	58 - 650 A		
t-DDT	35.4	77	28	4 - 128	91 - 129	0.183 T	52 - 475 H	7	
	2360	4208	3784	(b)	8273 - 10750	0.0021 - 0.012 B	106 - 1386 A		12000
2,4-D			30						
Diazinon	3 U	0.36 J	0.13			0.0033 T	0.2 - 530 H		
						0.0004U - 0.030 B	0.2 - 1.5 A		
% TOC	1.5	1.83	0.74	0.2 - 2.0	1.1 - 1.2		0.62 - 1.6		
% solids	67	66	74.1				0.52 - 1.4		
% sand	11	12	71						
% silt	78	72	16						
% clay	11	12	13						

U - The analyte was not detected at or above the reported result.
J - The analyte was positively identified. The reported result is an estimate.

T - Thorp Rd
B - Birchfield Rd

H - soil from hops field
A - soil from apple orchard

Lowest Effect Level - Indicates a level of sediment contamination that can be tolerated by most benthic organisms.
Severe Effect Level - Pronounced disturbance of sediment dwelling organisms can be expected. Contaminant concentration would be detrimental to the majority of benthic species.
ug/Kg OC - Results normalized to total organic carbon (result / %TOC as decimal)

(a) - Samples collected from both the A and B soil horizon; the lower values are generally associated with the B horizon while the high values are from the A horizon: the A horizon defined as 0 to 6 inches soil depth; the B horizon defined as 6 to 9 inches depth.
(b) - TOC normalized results not presented due to the relatively large number of samples obtained with varying TOC, grain sizes, and contaminant concentrations.

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Water

Concentrations of DDT compounds in water from sub-basin D1 are similar to concentrations found in the Moxee Drain by other investigators (Table 3). Levels of DDT compounds found in this study exceeded Washington State water quality standards for freshwater chronic effects on aquatic biota. These standards have also been consistently exceeded in sample results of other investigations. Freshwater acute standards for DDT and its metabolites were not exceeded in any samples collected by this or other referenced studies in the Moxee drainage.

The herbicide 2,4-D was similarly detected in this study as well as by others. Washington State has no specific numerical criteria regarding 2,4-D and its potential effects on aquatic biota. Diazinon was not detected in water from this study, but was detected by Johnson *et al.* (1986) and Rinella *et al.* (1992).

Sediments

Concentrations of DDT compounds from the D1 sediment basin and D1 tailwater settled sediment from this study were similar to Moxee Drain sediment concentrations reported by other investigators (Table 4). Concentrations of DDT compounds from tailwater settled sediment and the D1 sediment basin were similar even though the sediment basin sample had a much larger proportion of sand-sized particles. Diazinon was also detected in both tailwater settled sediment and sediment basin sediment. Table 4 lists Canadian guidance criteria for DDT compounds in sediment. These criteria are used by Ontario for guiding management decisions regarding preventative and remedial actions related to freshwater sediments and their threat to aquatic biota. (United States criteria are not yet finalized and appear to be less comprehensive than Canadian guidelines presented here). Use of the Canadian guidelines require that results be normalized to TOC. The "Lowest Effect Level" of the Provincial Sediment Quality Guidelines criteria were exceeded for DDD, DDE, and t-DDT in various samples from this study. The "Severe Effects Level" criteria were not exceeded by any results from this study, but were approached in samples collected by Rinella *et al.* (1992).

CONCLUSIONS

1. The project's primary objective to evaluate BMP effectiveness on water quality was achieved in part. The "before BMP/after BMP" evaluation strategy used in this study was confounded by climatic factors. The "upstream/downstream" strategy proved to be insensitive due to high variability of quality in receiving waters and input waters. However, data suggests that BMPs contributed to improved water quality in the lower drainage of the study area. Climatic factors leading to reduced irrigation water supply and availability also appear to have contributed to improved water quality. Other findings included:

a. Water quality in streams influenced by irrigation return flows was highly variable. Large changes in pollutant concentrations and loads (generally greater than 50%) needed to occur in order to be deemed statistically significant.

b. A high percentage of land was treated with BMPs (about 70% of furrow-irrigated hops acreage in the lower drainage), which was critical for evaluating water quality changes in the project area versus a reference site.

c. Water quality improvements at project site D1 were substantial and generally greater than those at reference site M1. Pollutant reductions were realized for TSS (86%), TSS load (90%), Imhoff SS (99%), nephelometric turbidity (63%), absorbtometric turbidity (75%), ammonia (56%), and ammonia load (60%). An 18% reduction in the median flow between years was not significant. The combination of project BMPs and climate-induced factors were probable causes for water quality improvement at this site. Partitioning the water quality change among these various causes was not possible with the study design used.

d. Water quality improvements at reference site M1 were also substantial. Median pollutant reductions were realized for TSS load (74%), Imhoff SS (93%), nephelometric turbidity (52%), and absorbtometric turbidity (48%). A 28% reduction in flow at this sample site was also statistically significant. A 63% reduction in TSS and a 74% reduction in TSS load were not significant. Climate-induced reduction of irrigation water supply was a probable cause for water quality improvement at site M1. Reduced irrigation water allotments likely necessitated some level of irrigation water management, thus contributing to improved water quality.

2. The study objective to characterize pesticides in water and sediments from a tailwater drain was achieved. Concentrations of detected pesticides were compared to criteria and the results of other studies in the Moxee Drain area. Key findings were:

a. Concentrations of DDT compounds in water from the lower drainage (site D1) were similar to concentrations found in the Moxee Drain by other investigators. Levels of DDT compounds in water found in this study exceeded Washington State water quality standards for freshwater chronic effects on aquatic biota. These standards have been consistently exceeded as evidenced by the results of other investigations in the Moxee Basin. Freshwater acute standards were not exceeded in any samples collected by this or other studies in the area.

b. Concentrations of DDT compounds from the sediment basin and D1 tailwater settled sediment from this study were similar to Moxee Drain sediment concentrations reported by other investigators. The "Lowest Effect Level" of the Ontario Provincial Sediment Quality Guidelines criteria were exceeded for DDD, DDE, and t-DDT in various samples. The "Severe Effects Level" was not exceeded by any results from this study, but it was approached in samples collected by Rinella *et al.* (1992).

c. Diazinon was detected in both tailwater settled sediment as well as in sediment basin sediment. 2,4-D was detected in water during this and other studies, and in sediment during this study.

3. The third study objective to provide data for longer term assessment of BMP effectiveness related to water quality and pollutant transport was achieved. While this objective was broadly stated, the methods, results, and findings from this study can help in the design of future BMP evaluation and water quality studies specific to irrigated agricultural lands in the Moxee Valley:

   a. Specific objectives of future water quality or BMP effectiveness studies will determine whether data from this study can appropriately be used as "baseline" data for future BMP evaluations.

   b. Sediment-related parameters were most indicative of water quality improvements in this study. Project BMPs focused on sediment retention rather than nutrient or pesticide management. Nutrients were less useful parameters because of presence in groundwater and baseflow at greater levels than irrigation return water (nitrate/nitrite), effects of equilibrium dynamics between sediment-bound and dissolved phases (phosphorus), and background levels similar to levels found in irrigation return water (ammonia).

   c. The effects of external variables on water quality can be substantial. Such variables must be considered and may need to be thoroughly characterized before undertaking future BMP evaluation studies. These variables include water quality variability, sample timing (e.g. during or not during irrigation), tailwater flow regimes, irrigation delivery behaviors and records (e.g. normal supply, supplemental water from wells and other sources), impacts and influence of growing season characteristics (e.g. crop-water needs), and irrigation water availability and allotments.

4. The fourth objective, to provide water quality information to the agricultural community within the study area and the larger NYCD boundaries, was achieved. While this objective was also broadly stated, this report presents water quality data, information, and discussion. The agricultural community may find these useful in the coming years as awareness of water quality problems and need for solutions increase.

REFERENCES

APHA *et al.*, 1989. Standard Methods for the Examination of Water and Wastewater. 17th Edition. American Public Health Assn., American Water Works Assn., and Water Pollution Control Federation, Washington, D.C.

Anderson & Associates, 1993. "Furrow mulching effective in reducing waste in tillage and irrigation." in Yakima Basin Resource News, Winter 92/93. Anderson & Associates, Vancouver, WA. p. 11.

Bureau of Reclamation, 1992. News Release dated June 5, 1992 regarding Yakima Project Total Water Supply Available analyses and need for prorationing.

Davis, D.A., 1993. Washington State Pesticide Monitoring Program--Reconnaissance Sampling of Surface Waters (1992). Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, WA.

Ecology, 1979. Irrigated Agriculture Water Quality Management Plan, Section 208, P.L. 95-217. Washington State Department of Ecology, publication # 79-5b, Olympia, WA.

------, 1991a. Manchester Environmental Laboratory Uses's Manual. 3rd rev., Manchester Environmental Laboratory, Manchester, WA.

------, 1991b. Guidelines and Specifications for Preparing Quality Assurance Project Plans. Ecology Publication 91-16, Quality Assurance Section, Manchester, WA.

------, 1992. 1992 Statewide Water Quality Assessment, 305(B) Report. Ecology Publication # 92-04. Olympia, WA.

Environmental Protection Agency, 1986. Quality Criteria for Water 1986. EPA publication #EPA 440/5-86-001. Office of Water Regulations and Standards, Washington D.C.

------, 1983 rev. Methods for Chemical Analysis of Water and Wastes. EPA publication #EPA-600/4-79-020 (Revised in March 1983).

Gilbert, R.M., 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold Company, Inc., New York, NY.

Grant, D.M., 1989. ISCO Open Channel Flow Measurement Handbook. 3rd ed., ISCO, Inc., Lincoln, NE

Johnson, A., D. Norton and B. Yake, 1986. Occurrence and Significance of DDT Compounds and Other Contaminants in Fish, Water, and Sediment from the Yakima River Basin. Water Quality Investigations Section, Olympia, WA. Ecology Report Number 86-5.

King, L.G., B.L. McNeal, F.A. Ziari, and S.C. Matulich, 1984. On Farm Improvements to Reduce Sediment and Nutrients in Irrigation Return Flow. EPA publication # EPA-600/2-84-044, Washington State University, Pullman, WA.

Larson, A.G., 1993. Pesticide Residues in the Moxee and Ahtanum Surficial Aquifer. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, WA.

North Yakima Conservation District, 1992. Moxee/Naches Water Quality Project Final Report. NYCD, Yakima, WA.

------, 1993a. Moxee Drain BMP Implementation Demonstration Project Final Report. NYCD, Yakima, WA.

------, 1993b. Personal communication with Michael Tobin, July 1993. Yakima, WA.

Persaud, D., R. Jaagumagi, and A. Hayton, 1992. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Water Resources Branch, Ontario Ministry of the Environment, Canada. Log 92-2309-067.

Puget Sound Estuary Program, 1991. Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound. Puget Sound Estuary Program/Tetra Tech Inc. Seattle, WA.

Rinella, J.F., S.W. McKenzie, J.K. Crawford, W.T. Foreman, P.M. Gates, G.J. Fuhrer, and M.L. Janet, 1992. Surface-Water-Quality Assessment of the Yakima River Basin, Washington: Pesticide and Other Trace-Organic-Compound Data for Water, Sediment, Soil, and Aquatic Biota, 1987-91. National Water Quality Assessment Program (NAWQA), USGS Open File Report 92-644, Portland, OR.

South Yakima Conservation District, 1982. Model Implementation Project Final Report, October 1982. South Yakima Conservation District, Toppenish, WA.

U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, Soil Conservation Service, Agricultural Research Services, Idaho Division of Environmental Quality, Twin Falls and Snake River Soil Conservation Districts, and City of Twin Falls, ID., 1991. Rock Creek Rural Clean Water Program Final Report, 1981-1991, An Interagency Report. Twin Falls, ID. 328 pp.

Wilkinson, L., 1990. SYGRAPH: The System for Graphics. SYSTAT, Inc., Evanston, IL.

APPENDICES

Appendix A. General Chemistry Water Quality Monitoring Data.

Period (1)	Station	Date	Time	Lab #	pH	Temp.	Cond.	Imhoff	Turb.	Flow	Turb.	TSS	NH3-N	NO2/3-N	Tphos	Irrigation
					I<---------field measurements----------->I						I<-----------laboratory analyses-------------->I					
					SU	deg.C	uS/cm	mL/L	FTU	cfs	NTU	mg/L	mg/L	mg/L	mg/L	D1 Delivery cfs
E	M2	04/09/91	12:55	158402	8.5	10.0	365		35	10.17 r	6.8	33	0.022	0.700	0.168	
E	M2	04/10/91	11:10	158412	8.4	9.1	380		252	5.51 r	110	400	0.054	0.910	0.432	
E	M2	04/15/91	14:25	168422	8.5	11.1	348		88	12.28 r	30	104	0.034	0.593	0.227	
E	M2	04/16/91	10:55	168432	8.4	10.6	354		57	12.93 r	22	78	0.041	0.592	0.201	
E	M2	04/24/91	13:35	178442	8.8	14.9	337	0.01 t	94	11.10 r	31	135	0.052	0.528	0.275	
E	M2	04/25/91	10:40	178452	8.3	10.5	388	0.06	214	10.71 r	72 J	350	0.046	0.816	0.390	
M	M2	05/29/91	15:15	228502	8.4	16.5	368	0.01 t	52	14.86 r	22	73	0.046	0.643	0.148	
M	M2	05/30/91	12:39	228512	8.6	15.3	345	0.10	136	16.04 r	44	232	0.080	0.585	0.127	
M	M2	06/04/91	14:30	238522	8.6	17.6	350	0.01 t	55	11.71 r	22	69	0.024	0.604	0.294	
M	M2	06/05/91	12:15	238532	8.2	12.9	334	0.13	145	14.19 r	49	374	0.061	0.610	0.467	
M	M2	06/10/91	11:50	248542	8.2	14.4	330	0.04	43	15.78 r	18	85	0.011	0.514	0.239	
M	M2	06/11/91	10:30	248552	8.3	17.0	334	0.02	45	16.67 r	19	105	0.01 U	0.531	0.278	
	M2	07/11/91	13:15			19.8		0.30	120	7.46 r						
L	M2	07/24/91	14:05	308402	8.2	22.2	315	0.57	300	15.16 r	130	550	0.048	0.868	0.057	
L	M2	07/25/91	10:15	308412	8.1	17.4	320	0.27	155	18.36 r	50	306	0.017	0.729	0.434	
L	M2	07/30/91	13:15	318422	8.2	20.2	320	0.33	150	18.65 r	50	323	0.036	0.750	0.324	
L	M2	07/31/91	10:25	318432	8.0	17.0	330	0.20	144	15.93 r	40	146	0.038	0.875	0.354	
L	M2	08/05/91	13:10	328442	8.1	17.5	325	0.27	100	23.65 r	37	185	0.075	0.817	0.309	
L	M2	08/06/91	10:20	328452	8.1	17.8	338	0.20	100	24.50 r	39	200	0.037	0.755	0.182	
	M2	08/22/91	11:55			21.8		0.22		23.19 r						
	M2	09/11/91	12:00			17.0		0.07	55	15.90 r						
	M2	10/02/91	14:00			16.5		0.04	90	14.57 r						
	M2	10/09/91	14:40			14.0		0.01 t	50	16.49 r						
	M2	10/24/91	15:00			12.3		0.01 t	13	8.63 r						
	M2	11/06/91	09:10			8.3		0.01 t	12	6.82 r						
	M2	11/20/91	11:40			10.0		0.01 t	5	9.15 r						
	M2	12/05/91	10:00			9.3		0.01 t	5	5.26 r						
	M2	12/18/91	09:00			9.0		0.01 t	6	0.64 r						
	M2	01/16/92	10:00			7.3		0.01 t	12	0.33 r						
off	M2	02/19/92	14:10	88502	8.4	9.1	855	0.01 ta		3.47 r	5	19	0.019	2.39	0.314	
off	M2	02/20/92	10:05	88512	7.8	8.2	850	0.01 ta	25	4.16 r	5.2	32	0.026	2.27	0.325	
off	M2	02/25/92	12:50	98522	8.1	10.6	880	0.01 ta	24	4.06 r	7.1	52	0.030	2.26	0.383	
off	M2	02/26/92	09:25	98532	8.1	9.8	860	0.01 ta	53	4.02 r	20	51	0.257	2.41	0.291	
off	M2	03/02/92	13:45	108542	8.5	11.2	850	0.01 ta	28	3.91 r	12	36	0.037	2.89	0.355	
off	M2	03/03/92	09:05	108552	8.3	9.5	878	0.01 ta	63	3.97 r	23	57	0.046	2.45	0.404	
E	M2	04/13/92	13:55	168602	8.2	12.7	340	0.05	44	18.18 r	18	72	0.043	1.02	0.227	
E	M2	04/14/92	10:05	168612	8.2	11.0	362	0.01 ta	20	16.03 r	5.8	37	0.021	0.924	0.162	
E	M2	04/22/92	14:30	178622	8.1	12.4	400	0.01 ta	21	11.76 r	6.9	29	0.01 U	0.832	0.175	
E	M2	04/23/92	09:30	178632	7.6	8.9	435	0.01 t	44	7.51 r	22	51	0.020	1.45	0.215	

Appendix A. General Chemistry Water Quality Monitoring Data.

					<---------field measurements---------->						<-----------laboratory analyses--------------->					Irrigation
Period (1)	Station	Date	Time	Lab #	pH SU	Temp. deg.C	Cond. uS/cm	Imhoff mL/L	Turb. FTU	Flow cfs	Turb. NTU	TSS mg/L	NH3-N mg/L	NO2/3-N mg/L	Tphos mg/L	D1 Delivery cfs
E	M2	04/28/92	12:45	188642	8.2	15.9	370	0.01 ta	16	13.68 r	3.4	24	0.01 U	0.711	0.161	
E	M2	04/29/92	09:45	188652	7.8	13.4	400	0.01 ta	15	14.78 r	4.5	30	0.01 U	0.854	0.161	
M	M2	05/27/92	14:35	228802	8.1	18.2	377	0.01 t	45	12.78 r	19	69	0.032	1.02	0.221	
M	M2	05/28/92	10:55	228812	8.0	16.1	392	0.01 t	60	11.91 r	27	83	0.040	0.906	0.265	
M	M2	06/02/92	14:00	238822	7.8	18.7	415	0.01 t	38	10.23 r	13	32	0.045	0.977	0.229	
M	M2	06/03/92	11:00	238832	7.9	15.2	350	0.01 t	47	12.42 r	21	64	0.042	0.746	0.225	
M	M2	06/08/92	13:15	248842	7.8	17.4	340	0.01 t	25	13.14 r	7.5	35	0.036	0.600	0.151	
M	M2	06/09/92	09:50	248852	7.8	14.8	368	0.01 t	50	11.86 r	25	93	0.034	0.686	0.147	
	M2	06/17/92	09:55			14.4		0.01 t	42	13.98 r						
	M2	07/01/92	10:15			16.8		0.13	148	12.13 r						
	M2	07/08/92	10:45			16.3		0.01 t	72	4.42 r						
	M2	07/17/92	10:15			17.8		0.05	82							
L	M2	07/22/92	13:55	308702	7.6	18.8	361	0.17	90	12.40 r	43	129	0.041	1.02	0.397	
L	M2	07/23/92	10:25	308712	7.5	16.4	372	0.05	285	15.19 r	90	248	0.139	1.98	0.451 J	
L	M2	07/28/92	13:50	318722	7.7	19.5	415	0.01 t	37	11.49 r	16	50	0.037	0.989	0.266	
L	M2	07/29/92	09:40	318732	7.9	17.3	395	0.01 t	71	10.74 r	35	112	0.050	0.905	0.267	
L	M2	08/03/92	14:10	328742	7.7	20.5	370	0.01 t	42	10.43 r	17	52	0.033	0.950	0.273	
L	M2	08/04/92	09:25	328752	7.8	17.5	343	0.01 t	51	13.03 r	25	76	0.040	0.935	0.285	
	M2	08/20/92	14:00			20.0		0.01 t	62	8.17 r						
E	D1	04/09/91	13:10	158403	8.7	13.4	920		48	0.372	7.9	47	0.045	1.79	0.186	0.40
E	D1	04/10/91	11:55	158413	8.3	11.6	540		1700	0.542	620 J	2980 J	0.097	2.17	0.904	0.41
E	D1	04/15/91	15:05	168423	8.8	11.7	595		120	0.542	45	360	0.069	3.76	0.267	0.55
E	D1	04/16/91	11:20	168433	8.8	11.7	520		650	0.542	224	893	0.130 d	3.07 d	0.096	0.68
E	D1	04/24/91	16:10	178443	8.4	17.2	900	0.01 t	300	0.234	68	416	0.113	5.79	0.412	0.42
E	D1	04/25/91	11:20	178453	8.3	12.0	690	1.47	680	0.299	290 J	1290	0.083	4.13	1.01	0.67
M	D1	05/29/91	16:40	228503	8.2	15.8	680	0.47	676	0.542	164	1090	0.137	5.06	0.178	1.97
M	D1	05/30/91	14:10	228513	8.1	21.5	390	2.87	1500	0.963	252	3160	0.258	2.67	0.281	2.94
M	D1	06/04/91	14:40	238523	8.3	20.7	750	1.00	1441	0.372	357	1860	0.117	6.39	0.286	1.45
M	D1	06/05/91	08:40	238562	8.2	11.6	415		1000	0.738	236	3690	0.137	2.60	0.712	1.25
M	D1	06/05/91	12:25	238533	8.2	12.7	382	3.23	756	0.963	195	3140	0.164	2.38	0.544	1.25
M	D1	06/10/91	09:00	248565	8.3	13.5	925		100	0.299	39	191	0.017	7.22	0.218	0.45
M	D1	06/10/91	12:00	248543	8.3	18.0	910	0.02	120	0.299	46	224	0.030	7.12	0.242	0.45
	D1	06/11/91	10:40	248553	8.5	15.6	880	0.02	100	0.299	37	174	0.017	7.30	0.222	0.13
	D1	07/11/91	13:30			24.7		0.70	914	0.903						2.23
L	D1	07/24/91	14:15	308403	8.0	23.9	260	2.50	910	1.800	335	2240	0.138	1.22	0.088 E	5.47
L	D1	07/25/91	10:25	308413	8.0	19.6	245	2.50	760	1.351	320	2140	0.123	1.21	0.105	5.07
L	D1	07/30/91	13:25	318423	8.1	24.5	245	2.50	700	1.800	230	2140	0.094	0.96	0.395	3.16

Appendix A. General Chemistry Water Quality Monitoring Data.

					I<---------field measurements----------->I						I<-----------laboratory analyses--------------->I					Irrigation
Period (1)	Station	Date	Time	Lab #	pH SU	Temp. deg.C	Cond. uS/cm	Imhoff mL/L	Turb. FTU	Flow cfs	Turb. NTU	TSS mg/L	NH3-N mg/L	NO2/3-N mg/L	Tphos mg/L	D1 Delivery cfs
L	D1	07/31/91	08:35	318468	7.8	17.4	250	2.30	570	1.351	200	2230	0.087	1.10	0.498	3.40
L	D1	07/31/91	10:35	318433	8.0	18.9	253	1.90	650	1.351	200	1430	0.098	1.24	0.509	
L	D1	08/05/91	13:20	328443	7.7	18.5	275	0.38	340	0.903	120	378	0.130	1.63	0.452	2.43
L	D1	08/06/91	10:30	328453	7.9	18.1	460	0.01 t	130	0.738	47	137	0.136	3.03	0.287	3.38
	D1	08/22/91	12:05			22.8		0.53	220	1.962						4.48
	D1	09/11/91	12:10			17.3		0.50	2100	0.738						1.04
	D1	10/02/91	14:10			20.0		1.50	950	1.962						3.81
	D1	10/09/91	14:50			16.8		0.53	420	1.644						4.63
	D1	10/24/91	15:05			13.3		0.01 t	180	0.636						
	D1	11/06/91	09:20			8.5		0.01 t	50	0.589						
	D1	11/20/91	11:50			10.5		0.01 t	40	0.687						
	D1	12/05/91	10:10			9.5		0.01 t	35	0.453						
	D1	12/18/91	09:10			9.0		0.01 t	42	0.636						
	D1	01/16/92	10:10			7.0		0.01 t	35	0.335						
off	D1	02/19/92	14:30	88503	8.1	9.8	935	0.01 ta		0.453	33	115	0.119	6.96	0.217	
off	D1	02/20/92	10:30	88513	8.0	7.8	905	0.01 ta	98	0.542	44	152	0.195	6.74	0.250	
off	D1	02/25/92	13:25	98523	8.4	10.7	920	0.01 ta	49	0.453	26	79	0.073	7.14	0.201	
off	D1	02/26/92	09:50	98533	8.3	9.1	910	0.01 ta	39	0.413	22	72	0.054	6.89	0.196	
off	D1	03/02/92	14:20	108543	8.5	11.4	920	0.01 ta	18	0.453	33	87	0.056	7.19	0.229	
off	D1	03/03/92	09:45	108553	8.3	8.7	910	0.01 ta	58	0.453	26	90	0.064	6.59	0.225	
E	D1	04/13/92	14:05	168603	8.0	17.0	925	0.01 ta	130	0.335	51	101	0.251	7.39	0.157	1.17
E	D1	04/14/92	10:25	168613	8.2	10.7	940	0.01 ta	41	0.299	18	41	0.051	7.20	0.132	1.17
E	D1	04/22/92	15:20	178623	8.0	16.9	810	0.01 ta	98	0.299	40	74	0.049	5.88	0.196	1.17
E	D1	04/23/92	09:40	178633	8.0	6.5	595	0.33	225	0.738	80	358	0.024	4.05	0.093	1.17
E	D1	04/28/92	13:10	188643	8.2	17.4	850	0.01 ta	24	0.299	8.5	18	0.012	6.92	0.095	1.17
E	D1	04/29/92	10:00	188653	8.0	12.0	780	0.01 ta	25	0.453	9.1	21	0.016	7.13	0.097	1.13
M	D1	05/27/92	14:45	228803	7.9	22.5	560	0.01 t	250	0.738	113	282	0.096	5.03	0.443	2.09
M	D1	05/28/92	11:05	228813	8.0	18.1	465	0.01 t	355	0.847	150	333	0.120	3.82	0.432	1.34
M	D1	06/02/92	14:10	238823	8.0	21.2	645	0.01 t	70	0.636	39.5	120	0.075	4.87	0.228	2.04
M	D1	06/03/92	09:00	238860	7.7	12.8	590		220		90	207	0.098	5.27	0.078	2.60
M	D1	06/03/92	11:10	238833	8.0	16.1	745	0.01 t	295	0.372	110	272	0.053	5.70	0.130	2.60
M	D1	06/08/92	13:30	248843	7.8	22.7	590	0.01 t	172	0.738	70	265	0.057	4.09	0.292	2.27
M	D1	06/09/92	10:00	248853	7.8	16.2	485	0.01 t	133	0.738	60	225	0.053	3.04	0.042	2.28
	D1	06/17/92	10:10			14.9		0.01 t	43	0.738						1.98
	D1	07/01/92	10:30			17.8		1.53	680	1.086						2.53
	D1	07/08/92	10:55			17.3		0.30	180	1.215						2.40
	D1	07/17/92	10:30			17.2		0.01 t	72	0.453						2.36
L	D1	07/22/92	14:05	308703	7.6	20.6	470	1.25	550	0.738	240	1090	0.054	2.59	0.951	2.04
L	D1	07/23/92	10:35	308713	7.5	16.2	400	0.83	610	1.351	255	741	0.114	4.18	0.825	1.70

Appendix A. General Chemistry Water Quality Monitoring Data.

					I<---------field measurements------------>I								I<-------------laboratory analyses--------------->I						Irrigation
Period (1)	Station	Date	Time	Lab #	pH	Temp.	Cond.	Imhoff		Turb.	Flow		Turb.	TSS	NH3-N		NO2/3-N	Tphos	D1 Delivery
					SU	deg.C	uS/cm	mL/L		FTU	cfs		NTU	mg/L	mg/L		mg/L	mg/L	cfs
L	D1	07/28/92	14:00	318723	7.7	19.7	530	0.01	t	32	0.636		14	38	0.043		2.25	0.280	1.27
L	D1	07/29/92	09:50	318733	7.8	17.5	420	0.50		170	0.963		75	520	0.048		1.60	0.172	1.45
L	D1	08/03/92	14:20	328743	7.9	23.4	380	0.01	t	60	1.086		23	84	0.045		0.985	0.390	2.07
L	D1	08/04/92	09:35	328753	7.8	18.2	225	0.18		43	1.351		24	160	0.046		1.25	0.456	2.45
L	D1	08/20/92	14:10			20.0		0.01	ta	74	0.542								3.22
E	M1	04/09/91	13:20	158401	8.6	10.3	335			34	9.79		6.2	33	0.019		0.411	0.149	
E	M1	04/10/91	11:40	158411	8.4	9.3	350			20	4.96		6	10	0.013		0.620	0.175	
E	M1	04/15/91	14:35	168421	8.5	10.9	338			92	11.73		32	83	0.040		0.426	0.219	
E	M1	04/16/91	11:10	168431	8.3	10.1	344			21	12.38		8.6	26	0.01	U	0.434	0.138	
E	M1	04/24/91	16:30	178441	8.8	14.8	320	0.01	t	82	10.86	r	29.5	121	0.043		0.371	0.263	
E	M1	04/25/91	10:55	178451	8.3	10.8	389	0.01	t	440	10.40		82	140	0.042		0.675	0.354	
M	M1	05/29/91	15:55	228501	8.5	15.7	350	0.01	t	31	14.31		12	34	0.037		0.479	0.135	
M	M1	05/30/91	13:55	228511	8.7	16.1	342	0.01	t	33	15.06		14	44	0.030		0.453	0.144	
M	M1	06/04/91	14:35	238521	8.7	17.1	335	0.01	t	19	11.33	r	11	26	0.014		0.422	0.173	
M	M1	06/05/91	12:20	238531	8.2	12.8	324	0.17		101	13.22		39	260	0.055		0.520	0.363	
M	M1	06/10/91	11:55	248541	8.1	17.9	310	0.01	t	35	15.47		15	62	0.012		0.450	0.226	
M	M1	06/11/91	10:35	248551	8.3	16.8	330	0.01	t	28	16.36		11.5	44	0.01	U	0.484	0.215	
	M1	07/11/91	13:25			19.4		0.17		109	6.55	r							
L	M1	07/24/91	14:10	308401	8.2	21.0	330	0.40		160	13.35		75	411	0.036		0.834	0.082	
L	M1	07/25/91	10:20	308411	8.1	16.8	321	0.20		105	16.99		35	209	0.016		0.682	0.239	
L	M1	07/30/91	13:20	318421	8.2	18.9	330	0.20		107	16.84		37	189	0.039		0.717	0.355	
L	M1	07/31/91	10:30	318431	8.1	16.4	339	0.10		79	14.57		30	105	0.050		0.831	0.330	
L	M1	08/05/91	13:15	328441	8.0	17.2	328	0.23		90	22.73		35	213	0.044		0.769	0.264	
L	M1	08/06/91	10:25	328451	8.1	17.6	330	0.20		95	23.74		36	231	0.051		0.700	0.364	
	M1	08/22/91	12:00			21.0		0.01	t	52	21.21	r							
	M1	09/11/91	12:05			17.0		0.10		45	15.15	r							
	M1	10/02/91	14:05			16.3		0.01	t	23	12.60	r							
	M1	10/09/91	14:45			13.8		0.01	t	20	14.83	r							
	M1	10/24/91	15:10			12.3		0.01	t	10	7.99	r							
	M1	11/06/91	09:15			8.5		0.01	t	7	6.23	r							
	M1	11/20/91	11:45			10.0		0.01	t	5	8.46	r							
	M1	12/05/91	10:05			9.0		0.01	t	4	4.80	r							
	M1	12/18/91	09:05			9.8		0.01	t	5									
	M1	01/16/92	10:05			7.0		0.01	t	5									
off	M1	02/19/92	14:20	88501	8.5	9.0	850	0.01	ta		3.01		1.2	4	0.014		1.60	0.334	
off	M1	02/20/92	10:15	88511	8.2	8.4	850	0.01	ta	9	3.62		2	7	0.01	U	1.70	0.337	
off	M1	02/25/92	13:10	98521	8.5	10.6	880	0.01	ta	14	3.6		3.7	17	0.025		1.69	0.339	

Appendix A. General Chemistry Water Quality Monitoring Data.

Period (1)	Station	Date	Time	Lab #	|<------field measurements pH SU	Temp. deg.C	Cond. uS/cm	Imhoff mL/L	Turb. FTU	Flow cfs ------>|	|<------laboratory analyses Turb. NTU	TSS mg/L	NH3–N mg/L	NO2/3–N mg/L	Tphos mg/L ------>|	Irrigation D1 Delivery cfs
off	M1	02/26/92	09:35	98531	8.3	9.9	865	0.01 ta	52	3.6	20	44	0.272	1.86	0.303	
off	M1	03/02/92	14:05	108541	8.5	11.2	880	0.01 ta	19	3.45	5.6	23	0.029	1.98	0.378	
off	M1	03/03/92	09:30	108551	8.4	9.7	860	0.01 ta	61	3.51	24	50	0.042	1.88	0.427	
E	M1	04/13/92	14:00	168601	8.1	12.5	330	0.05	40	17.83	17	83	0.036	0.846	0.235	
E	M1	04/14/92	10:15	168611	8.2	11.1	345	0.01 ta	18	15.72	6	36	0.022	0.743	0.162	
E	M1	04/22/92	14:55	178621	8.1	12.4	394	0.01 ta	19	11.45	5.6	29	0.01 U	0.674	0.179	
E	M1	04/23/92	09:35	178631	7.9	9.5	387	0.01 t	19	6.77	6.4	17	0.01 U	0.901	0.184	
E	M1	04/28/92	13:00	188641	8.2	16.0	352	0.01 ta	14	13.37	3.7	25	0.013	0.545	0.175	
E	M1	04/29/92	09:55	188651	7.9	13.5	385	0.01 ta	15	14.32	4.1	29	0.01 U	0.635	0.169	
M	M1	05/27/92	14:40	228801	8.2	18.1	350	0.01 t	44	12.03	11	47	0.025	0.657	0.235	
M	M1	05/28/92	11:00	228811	8.2	16.1	377	0.01 t	28	11.05	13	45	0.023	0.620	0.231	
M	M1	06/02/92	14:05	238821	8.0	18.5	390	0.01 t	35	9.59	12	34	0.034	0.687	0.245	
M	M1	06/03/92	11:05	238831	8.0	15.1	328	0.01 t	34	12.04	13	58	0.032	0.603	0.260	
M	M1	06/08/92	13:20	248841	8.1	16.8	323	0.01 t	20	12.39	5.8	26	0.031	0.495	0.161	
M	M1	06/09/92	09:55	248851	7.9	14.8	355	0.01 t	44	11.11	24	103	0.034	0.578	0.252	
	M1	06/17/92	10:00			14.5		0.01 t	43	13.23 r						
	M1	07/01/92	10:20			15.8		0.01 t	47	11.03 r						
	M1	07/08/92	10:50			15.8		0.01 t	38	3.2 r						
	M1	07/17/92	10:25			16.9		0.10	84							
L	M1	07/22/92	14:00	308701	7.7	18.6	350	0.15	60	11.65	26	100	0.036	0.861	0.289	
L	M1	07/23/92	10:30	308711	7.6	16.5	370	0.05	184	13.83	60	214	0.140	1.50	0.552	
L	M1	07/28/92	13:55	318721	7.8	19.4	400	0.01 ta	37	10.85	15	52	0.035	0.870	0.271	
L	M1	07/29/92	09:45	318731	7.9	17.4	390	0.01 t	62	9.77	28	69	0.040	0.842	0.264	
L	M1	08/03/92	14:15	328741	7.8	21.1	370	0.01 t	41	9.34	16	52	0.035	0.926	0.258	
L	M1	08/04/92	09:30	328751	7.8	17.7	355	0.01 t	51	11.67	23	66	0.038	0.884	0.276	
	M1	08/20/92	14:05			19.0		0.01 t	60	7.62 r						
E	R1	04/09/91	10:35	158406	8.1	7.2	88		18	599	5.3	8	0.01 U	0.014	0.018	
E	R1	04/10/91	09:15	158416	8.3	7.0	92		17	599	5.6	7	0.01 U	0.01 U	0.017	
E	R1	04/15/91	12:15	168426	8.0	8.8	84		18	688	6.1	14	0.01 U	0.01	0.019	
E	R1	04/16/91	09:00	168436	7.8	8.6	78		14	688	6	15	0.01 U	0.019	0.019	
E	R1	04/24/91	13:05	178446	8.3	11.0	88		24	688	10	24	0.01 U	0.047	0.038	
E	R1	04/25/91	09:50	178456	8.0	8.8	79		24	688	10	20	0.01 U	0.054	0.043	
M	R1	05/29/91	13:40	228504	8.1	15.4	130		14	706	2.5	25	0.01 U	0.084	0.031	
M	R1	05/30/91	10:30	228514	8.6	13.0	112		11	725	2.4	9	0.01 U	0.121	0.032	
M	R1	06/04/91	12:05	238524	8.1	14.1	106		12	764	3.9	11	0.01 U	0.089	0.031	
M	R1	06/05/91	10:00	238534	8.3	12.9	101		11	744	4.1	11	0.01 U	0.090	0.037	
M	R1	06/10/91	10:00	248544	8.0	16.2	100		17	783	5.9	17	0.01 U	0.148	0.053	

Appendix A. General Chemistry Water Quality Monitoring Data.

Period (1)	Station	Date	Time	Lab #	<---field measurements--- pH SU	Temp. deg.C	Cond. uS/cm	Imhoff mL/L	Turb. FTU	Flow cfs --->	<---laboratory analyses--- Turb. NTU	TSS mg/L	NH3-N mg/L		NO2/3-N mg/L	Tphos mg/L --->	Irrigation D1 Delivery cfs
M	R1	06/11/91	08:45	248554	8.0	16.2	102		13	764	5.1	17	0.01	U	0.157	0.051	
	R1	07/11/91	11:35			18.9			14	865							
L	R1	07/24/91	11:15	308404	7.9	17.0	90		10	865	5	15	0.01	U	0.166	0.019	
L	R1	07/25/91	08:25	308414	7.8	16.4	84		13	865	5.8	17	0.01	U	0.172	0.026	
L	R1	07/30/91	11:00	318424	7.9	17.4	85		10	865	5.3	12	0.013		0.165	0.032	
L	R1	07/31/91	09:10	318434	8.1	16.9	82		12	865	5	16	0.01	U	0.150	0.034	
L	R1	08/05/91	10:55	328444	7.6	15.8	88		6	1114	4.9	9	0.01	U	0.140	0.029	
L	R1	08/06/91	08:40	328454	7.8	16.5	85		9	886	4.7	10	0.012		0.150	0.029	
	R1	08/22/91	11:00			19.3			11	824							
	R1	09/11/91	11:00			18.3			10	652							
	R1	10/02/91	13:00			16.8			6	517							
	R1	10/09/91	13:30			13.3			6	502							
off	R1	02/19/92								0							
off	R1	02/20/92								0							
off	R1	02/25/92								0							
off	R1	02/26/92								0							
off	R1	03/02/92								0							
off	R1	03/03/92								0							
E	R1	04/13/92	12:15	168604	6.4	10.1	91		10	616	3.4	7	0.016		0.100	0.041	
E	R1	04/14/92	08:50	168614	8.9	10.6	90		10	549	2.5	9	0.011		0.108	0.043	
E	R1	04/22/92	13:35	178624	8.0	11.0	108		10	472	3.6	8	0.01	U	0.091	0.039	
E	R1	04/23/92	08:25	178634	8.1	10.0	111		10	472	3.2	8	0.01	U	0.106	0.047	
E	R1	04/28/92	11:50	188644	8.7	14.8	94		10	599	2.3	14	0.01	U	0.077	0.036	
E	R1	04/29/92	08:50	188654	8.1	13.8	95		11	599	3.3	17	0.01	U	0.082	0.040	
M	R1	05/27/92	13:05	228804	7.0	16.8	90		10	557	3.2	14	0.01		0.106	0.030	
M	R1	05/28/92	09:45	228814	7.2	16.7	92		10	551	3.3	12	0.01	U	0.106	0.029	
M	R1	06/02/92	13:05	238824	6.8	17.2	90		10	545	2.5	12	0.014		0.116	0.033	
M	R1	06/03/92	09:45	238834	8.1	15.7	87		9	541	2.7	15	0.014		0.101	0.033	
M	R1	06/08/92	12:15	248844	6.8	15.2	80		9	541	2.7	12	0.021		0.097	0.025	
M	R1	06/09/92	08:50	248854	6.9	15.2	81		10	541	3.3	12	0.01	U	0.085	0.025	
	R1	06/17/92	09:15			15.3			12	549							
	R1	07/01/92	09:30			17.0			14	549							
	R1	07/08/92	09:45			18.0			10	549							
	R1	07/17/92	09:00			20.2			10	566							
L	R1	07/22/92	12:50	308704	6.7	20.0	80		9	582	2.6	15	0.014		0.083	0.036	
L	R1	07/23/92	09:00	308714	7.1	17.9	80		13	582	4.2	21	0.027		0.128	0.055	
L	R1	07/28/92	12:25	318724	6.8	20.5	90		7	566	5.7	5	0.016		0.076	0.031	
L	R1	07/29/92	08:40	318734	7.3	19.8	87		7	566	2.2	7	0.016		0.072	0.031	
L	R1	08/03/92	12:45	328744	6.6	20.6	77		10	599	2.5	13	0.012		0.055	0.022	

Appendix A. General Chemistry Water Quality Monitoring Data.

					I<---------field measurements----------->I						I<-----------laboratory analyses-------------->I					Irrigation
Period (1)	Station	Date	Time	Lab #	pH SU	Temp. deg.C	Cond. uS/cm	Imhoff mL/L	Turb. FTU	Flow cfs	Turb. NTU	TSS mg/L	NH3–N mg/L	NO2/3–N mg/L	Tphos mg/L	D1 Delivery cfs
L	R1	08/04/92	08:15	328754	7.2	20.5	78		8	616	2.4	11	0.01 U	0.046	0.025	
	R1	08/20/92	12:00			21.0			10	582						
E	R2	04/09/91	11:15	158407	8.2	7.2	93		19		5	9	0.01 U	0.01 U	0.016	
E	R2	04/10/91	09:40	158417	8.4	7.3	87		18		5.5	9	0.01 U	0.01 U	0.018	
E	R2	04/15/91	12:50	168427	8.0	8.8	83		19		7.3	18	0.01 U	0.01 U	0.017	
E	R2	04/16/91	09:30	168437	7.8	8.5	78		15		5.4	17	0.01 U	0.01 U	0.017	
E	R2	04/24/91	13:30	178447	8.3	10.9	84		24		11	26	0.01 U	0.042	0.045	
E	R2	04/25/91														
M	R2	05/29/91	14:25	228505	8.1	15.3	114		14		5.6	35	0.01 U	0.088	0.034	
M	R2	05/30/91	11:45	228515	8.4	13.6	114		12		3	11	0.01 U	0.121	0.031	
M	R2	06/04/91	13:25	238525	8.1	14.4	103		11		3.9	11	0.01 U	0.092	0.035	
M	R2	06/05/91	11:05	238535	8.1	13.0	105		12		3.4	13	0.01 U	0.094	0.032	
M	R2	06/10/91	10:35	248545	8.0	17.0	101		14		4.9	19	0.01 U	0.147	0.053	
M	R2	06/11/91	09:20	248555	8.0	16.4	101		14		4.2	16	0.01 U	0.154	0.048	
	R2	07/11/91	12:25			18.8			12							
L	R2	07/24/91	12:25	308405	7.9	19.3	80		12		4.6	14	0.01 U	0.156	0.023	
L	R2	07/25/91	09:20	308415	7.8	16.9	84		15		6.4	18	0.01 U	0.173	0.027	
L	R2	07/30/91	11:55	318425	8.0	17.7	82		10		5.3 J	14	0.012	0.140	0.034	
L	R2	07/31/91	09:45	318435	7.7	16.8	75		11		4.8	12	0.01	0.138	0.037	
L	R2	08/05/91	11:50	328445	7.7	15.9	76		7		5.6	13	0.012	0.149	0.030	
L	R2	08/06/91	09:45	328455	7.8	16.4	85		10		4.1	9	0.01 U	0.152	0.027	
	R2	08/22/91	11:35			19.5			9							
	R2	09/11/91	11:40			18.5			10							
	R2	10/02/91	13:40			17.0			8							
	R2	10/09/91	14:15			14.0			7							
off	R2	02/19/92														
off	R2	02/20/92														
off	R2	02/25/92														
off	R2	02/26/92														
off	R2	03/02/92														
off	R2	03/03/92														
E	R2	04/13/92	13:00	168605	8.0	10.5	91		10		3	7	0.01	0.113	0.041	
E	R2	04/14/92	09:20	168615	8.7	10.5	93		10		2.3	8	0.01 U	0.097	0.042	
E	R2	04/22/92	14:05	178625	8.4	11.3	108		10		3.3	8	0.01 U	0.089	0.040	
E	R2	04/23/92	08:50	178635	8.1	10.1	110		10		3.8	8	0.01 U	0.098	0.049	
E	R2	04/28/92	12:15	188645	8.6	14.8	96		11		2.5	12	0.01 U	0.060	0.031	
E	R2	04/29/92	09:25	188655	8.2	13.8	92		14		3.3	16	0.01 U	0.078	0.041	

Appendix A. General Chemistry Water Quality Monitoring Data.

					<---field measurements					--->	<---laboratory analyses				--->	Irrigation
Period (1)	Station	Date	Time	Lab #	pH SU	Temp. deg.C	Cond. uS/cm	Imhoff mL/L	Turb. FTU	Flow cfs	Turb. NTU	TSS mg/L	NH3-N mg/L	NO2/3-N mg/L	Tphos mg/L	D1 Delivery cfs
M	R2	05/27/92	13:55	228805	7.7	17.2	91		12		3	16	0.01 U	0.102	0.031	
M	R2	05/28/92	10:20	228815	7.9	16.8	92		11		3.2	14	0.01 U	0.105	0.030	
M	R2	06/02/92	13:30	238825	7.6	18.4	90		14		2.8	13	0.013	0.112	0.031	
M	R2	06/03/92	10:15	238835	8.1	16.7	86		12		2.9	13	0.012	0.100	0.028	
M	R2	06/08/92	12:45	248845	7.5	15.7	82		12		2.4	11	0.013	0.086	0.022	
M	R2	06/09/92	09:15	248855	7.7	15.2	80		10		2.7	11	0.015	0.085	0.028	
	R2	06/17/92	09:40			15.3			14							
	R2	07/01/92	09:55			17.5			14							
	R2	07/08/92	10:10			18.0			12							
	R2	07/17/92	09:55			20.2			10							
L	R2	07/22/92	13:20	308705	7.5	20.2	80		9		3.4	15	0.012	0.070	0.027	
L	R2	07/23/92	09:55	308715	7.6	18.3	82		12		4.5	25	0.024	0.119	0.039	
L	R2	07/28/92	13:10	318725	7.9	20.8	84		12		3.5	3	0.018	0.071	0.030	
L	R2	07/29/92	09:15	318735	8.0	19.8	88		9		3	6	0.015	0.065	0.026	
L	R2	08/03/92	13:40	328745	8.0	21.0	79		10		2.9	10	0.013	0.050	0.023	
L	R2	08/04/92	09:00	328755	7.9	20.5	76		12		2.4	11	0.01	0.042	0.035	
	R2	08/20/92	12:20			21.5			10							
E	QA.m1	04/09/91	13:30	158400	8.6	10.5	335		34		5.8	27	0.016	0.410	0.144	
E	QA.m2	04/10/91	11:25	158410	8.4	9.5	400		278		117	485 J	0.054	0.973	0.486	
E	QA.d1	04/15/91	15:15	168420	8.8	11.6	590				46	362	0.065	3.75	0.250	
E	QA.r2	04/16/91	09:40	168430	7.7	8.6	77.8		14		5.4	17	0.01 U	0.01 U	0.018	
E	QA.m1	04/24/91	16:30	178440							29.5	125	0.036	0.372	0.265	
E	QA.m2	04/25/91	11:30	178450	8.4	11.2	375		212		100 J	329	0.048	0.801	0.423	
M	QA.m2	05/30/91	12:37	228510	8.6	15.5	346		150		42	213 H	0.085	0.565	0.123	
M	QA.d1	06/04/91	14:40	238520	8.3	20.8	750		1440		355	1700	0.126	6.45	0.289	
M	QA.m1	06/05/91	12:20	238530	8.2	12.8	325		108		38	266	0.057	0.52	0.359	
M	QA.m2	06/11/91	10:30	248550	8.3	17.2	333		44		20	102	0.01 U	0.54	0.268	
L	QA.d1	07/24/91	14:15	308400							340	2140	0.131	1.03	0.134 E	
L	QA.m1	07/25/91	10:20	308410	8.1	16.8	319		109		33	218	0.018	0.674	0.232	
L	QA.r2	07/30/91	11:55	318420	8.0	18.0	85		10		6.7 J	16	0.012	0.135	0.035	
L	QA.m1	07/31/91	10:30	318430	8.1		338		80		30	105	0.046	0.824	0.336	
L	QA.r1	08/06/91	08:40	328450	7.8	16.5	85		8		4.7	10	0.013	0.150	0.030	
off	QA.d1	02/20/92	10:30	88510	8.1	7.8	905		98		45	154	0.197	6.74	0.248	
off	QA.m1	02/26/92	09:35	98530	8.3	9.9	870		52		21	43	0.273	1.91	0.303	
off	QA.m2	03/03/92	09:05	108550	8.3		880		62		23	59	0.042	2.46	0.401	
E	QA.r2	04/14/92	09:20	168610	8.8		94		10		2.1	8	0.01 U	0.099	0.042	
E	QA.m1	04/22/92	14:55	178620	8.1		392		19		5.9	28	0.01 U	0.673	0.173	

Appendix A. General Chemistry Water Quality Monitoring Data.

					field measurements						laboratory analyses						Irrigation
Period (1)	Station	Date	Time	Lab #	pH SU	Temp. deg.C	Cond. uS/cm	Imhoff mL/L	Turb. FTU	Flow cfs	Turb. NTU	TSS mg/L	NH3-N mg/L		NO2/3-N mg/L	Tphos mg/L	D1 Delivery cfs
E	QA.d1	04/23/92	09:40	178630	8.0		600				80	363	0.020		4.01	0.091	
E	QA.m2	04/28/92	12:45	188640	8.3		370		16		3.5	26	0.01	U	0.761	0.157	
E	QA.r1	04/29/92	08:50	188650	8.1		94		11		3.4	17	0.01	U	0.080	0.036	
M	QA.m2	05/27/92	14:35	228800	8.1		365		45		20.5	65	0.031		1.16	0.195	
M	QA.m1	05/28/92	11:00	228810	8.2		375		30		13	43	0.017		0.618	0.228	
M	QA.d1	06/02/92	14:10	238820	8.1		650		66		40	122	0.079		4.84	0.220	
M	QA.r2	06/03/92	10:15	238830	8.1		85		12		3.2	13	0.011		0.096	0.028	
M	QA.m1	06/08/92	13:20	248840	8.1		325		20		5.6	26	0.023		0.490	0.164	
M	QA.m2	06/09/92	09:50	248850	7.9		365		51		25	97	0.042		0.700	0.252	
L	QA.m2	07/22/92	13:55	308700	7.7		360		86		45	148	0.037		1.01	0.382	
L	QA.d1	07/23/92	10:35	308710	7.5		400		610		260	719	0.105		4.20	0.888	
L	QA.m1	07/28/92	13:55	318720	7.8		400		37		15	51	0.034		0.847	0.268	
L	QA.m2	07/29/92	09:40	318730	7.9		395		74		37	107	0.043		0.880	0.248	
L	QA.r2	08/03/92	13:40	328740	8.0		80		10		2.5	12	0.014		0.054	0.019	
L	QA.m2	08/04/92	09:25	328750	7.9		340		51		24	71	0.040		0.946	0.285	
M	RCE	05/30/91	11:00	228560	8.0	15.6	118		190	0.223	78	634	0.1		0.173	0.116	
M	RCE	06/04/91	12:40	238561	8.6	19.3	109		132	0.089	60	190	0.049		0.119	0.160	
M	RCE	06/05/91	10:35	238563	7.8	11.9	109		168	0.112	52	225	0.055		0.157	0.162	
L	RCE	07/24/91	11:50	308460	7.9	26.0	80		720	0.335	250	823	0.102		0.272	0.027	
L	RCE	07/25/91	08:50	308463	8.0	19.0	83		390	0.301	150	489	0.071		0.245	0.033	
L	RCE	07/30/91	11:30	318465	8.1	23.5	85		270	0.290	75	266	0.031		0.143	0.187	
L	RCE	07/31/91	09:30	318469	7.8	19.6	85		350	0.089	170	455	0.035		0.222	0.178	
L	RCE	08/05/91	11:20	328469	7.8	19.2	95		620	0.112	180	493	0.123		0.557	0.172	
L	RCE	08/06/91	09:20	328473	8.2	20.6	148		2400	0.007	700	1590	0.466		0.929	0.474	
L	RCE	07/23/92	09:20	308760	7.4	16.8	125		850	0.368	340	886	0.103		2.15	0.408	
L	RCE	07/28/92	12:40	318761	7.6	24.7	98		142	0.312	50	79	0.042		0.092	0.204	
L	RCE	07/29/92	08:55	318762	7.9	19.5	92		125	0.379	55	193	0.024		0.058	0.141	
L	RCE	08/03/92	13:15	328764	7.5	25.3	84		96	0.156	37	74	0.066		0.013	0.178	
L	RCE	08/04/92	08:35	328765	7.6	18.8	88		92	0.368	40	130	0.036		0.018	0.097	
L	RCM	07/24/91	12:55	308461	8.8	33.0	155		325	0.025	130	277	4.91		0.872	3.1	
L	RCM	07/25/91	09:30	308464	8.8	21.8	170		450	0.013	140	281	5.29		1.26	1.83	
L	RCM	07/30/91	12:20	318466	9.4	29.5	164		54	0.002	10	13	1.38		5.22	1.53	
L	RCM	08/05/91	12:10	328470	7.9	21.1	430		160	0.002	22	33	7.57		3.11	8.05	
M	RCW	06/10/91	11:00	248566	8.0	18.5	110		85	0.036	40	481	0.01	U	0.148	0.179	

Appendix A. General Chemistry Water Quality Monitoring Data.

					field measurements						laboratory analyses							Irrigation
Period (1)	Station	Date	Time	Lab #	pH SU	Temp. deg.C	Cond. uS/cm	Imhoff mL/L	Turb. FTU	Flow cfs	Turb. NTU	TSS mg/L	NH3-N mg/L		NO2/3-N mg/L		Tphos mg/L	D1 Delivery cfs
M	RCW	06/11/91	09:45	248567	8.0	16.3	101		84	0.036	31	476	0.01	U	0.151		0.404	
L	RCW	07/24/91	13:15	308462	8.6	33.0	130		30	0.004	4.5	8	0.154		1.49		1.29	
L	RCW	07/30/91	12:40	318467	7.9	30.7	147		25	0.007	3.2	3	0.353		3.39		1.07	
L	RCW	08/05/91	12:30	328471	7.4	20.8	244		70	0.002	15	12	0.305		4.14		2.27	
E	SM2	04/09/91	11:55	158405	8.5	9.7	118		30	9.90	7.1	30	0.015		0.024		0.042	
E	SM2	04/10/91	10:25	158415	8.5	8.9	111		22	7.30	9.6	14	0.01		0.019		0.026	
E	SM2	04/15/91	13:40	168425	9.1	11.5	94		18	7.36	5.8	11	0.01	U	0.01	U	0.021	
E	SM2	04/16/91	10:00	168435	8.8	10.0	93.6		20	6.49	7.3	21	0.01	U	0.01	U	0.027	
E	SM2	04/24/91	13:55	178445	9.3	14.9	96		19	5.70	9.9	13	0.01	U	0.01	U	0.029	
E	SM1	04/09/91	12:35	158404	8.4	9.6	106		30	8.02	7.1	32	0.012		0.022		0.040	
E	SM1	04/10/91	10:55	158414	8.5	9.2	110		19	7.55	7.5	11	0.01	U	0.018		0.028	
E	SM1	04/15/91	14:05	168424	9.0	11.0	95		17	7.10	5.9	12	0.01	U	0.012		0.021	
E	SM1	04/16/91	10:25	168434	8.7	9.7	93.3		25	6.88	7.6	23	0.01	U	0.019		0.026	
E	SM1	04/24/91	14:20	178444	9.1	14.2	97		21	5.94	8.9	20	0.01	U	0.029		0.038	

U – not detected at or above the reported result
J – the analyte was positively identified, the associated numerical result is an estimate
E – reported result is an estimate because of the presence of an interference (very high TSS in these cases)
H – sample holding time exceeded
d – the dissolved portion of the sample was analyzed (sample was filtered prior to analysis)
t – trace measured, <0.05 mL/L (value of 0.01 mL/L used in averaging)
ta – value of "trace" assigned, cone test not performed due to clarity of water and lack of substantial settleable solids
r – estimated from rating curve (M1) or estimated from addition of M1 and D1 flows (M2)
(1) Period
E – Early irrigation season
M – Middle irrigation season
L – late irrigation season

APPENDIX B. PESTICIDE LAB RESULTS.

CHLORINATED PESTICIDES/PCBs

Location:	D1	D1	D1	D1	D1	sed. basin	sed. basin	sed. basin	sed. basin
Type:	composite	composite	composite	composite	composite	grab	grab	grab	grab
Matrix:	water-total	water-total	water-total	water-total	water-total	sediment	sediment	sediment	sediment
Analysis:	sample	blank 1	blank 2	MS 1	MS 2	blank 1	sample	MS 1	MS 2
Sample Date:	6/8-9/92	6/8-9/92	6/8-9/92	6/8-9/92	6/8-9/92	8/4/92	8/4/92	8/4/92	8/4/92
Time:	1300/1000	1300/1000	1300/1000	1300/1000	1300/1000	1130	1130	1130	1130
Lab Log#:	248861	248861	248861	248861	248861	328763	328763	328763	328763
Lab:	Manchester	Manchester	Manchester	Manchester	Manchester	Manchester	Manchester	Manchester	Manchester
Method:	EPA 8080	EPA 8080	EPA 8080	EPA 8080	EPA 8080	EPA 8080	EPA 8080	EPA 8080	EPA 8080
Units:	ug/L	ug/L	ug/L	% recovery	% recovery	ug/kg	ug/kg	% recovery	% recovery
alpha-BHC	0.004 U	0.010 U	0.01 U			3.2 U	3.2 U		
beta-BHC	0.004 U	0.010 U	0.01 U			3.2 U	3.2 U		
gamma-BHC (Lindane)	0.004 U	0.010 U	0.01 U	80 %	90 %	3.2 U	3.2 U	83 %	98 %
delta-BHC	0.004 U	0.010 U	0.01 U			3.2 U	3.2 U		
Heptachlor	0.004 U	0.010 U	0.01 U	44 %	54 %	3.2 U	3.2 U	110 %	100 %
Aldrin	0.004 U	0.010 U	0.01 U	35 %	46 %	3.2 U	3.2 U	96 %	85 %
Heptachlor Epoxide	0.004 U	0.010 U	0.01 U			3.2 U	3.2 U		
Endosulfan I	0.004 U	0.010 U	0.01 U	80 %	93 %	3.2 U	3.2 U	110 %	120 %
4,4'-DDE	0.024	0.010 U	0.01 U			3.2 U	16		
Dieldrin	0.004 U	0.010 U	0.01 U			3.2 U	3.2 U		
Endrin	0.004 U	0.010 U	0.01 U	84 %	101 %	3.2 U	3.2 U	100 %	100 %
Endosulfan II	0.004 U	0.010 U	0.01 U			3.2 U	3.2 U		
4,4'-DDD	0.010	0.010 U	0.01 U			3.2 U	3.2 U		
Endrin Aldehyde	0.004 U	0.010 U	0.01 U			3.2 U	3.2 U		
4,4'-DDT	0.029	0.010 U	0.01 U	91 %	117 %	3.2 U	12	97 %	77 %
Endosulfan Sulfate	0.004 U	0.010 U	0.01 U			3.2 U	3.2 U		
Endrin Ketone	0.004 U	0.010 U	0.01 U			1.6 U	1.6 U		
Methoxychlor	0.004 U	0.010 U	0.01 U	137 %	145 %	3.2 U	3.2 U	130 %	140 %
Chlordane	0.040 U	0.10 U	0.10 U	61 %	74 %	3.2 U	3.2 U	86 %	96 %
Toxaphene	0.19 U	0.30 U	0.29 U			160 U	160 U		
Aroclor-1016	0.038 U	0.10 U	0.098 U			65 U	65 U		
Aroclor-1221	0.038 U	0.10 U	0.098 U			65 U	65 U		
Aroclor-1232	0.038 U	0.10 U	0.098 U			65 U	65 U		
Aroclor-1242	0.038 U	0.10 U	0.098 U			32 U	32 U		
Aroclor-1248	0.038 U	0.10 U	0.098 U			32 U	32 U		
Aroclor-1254	0.038 U	0.10 U	0.098 U			65 U	65 U		
Aroclor-1260	0.038 U	0.10 U	0.098 U			32 U	32 U		
surrogates and % recovery:									
4,4-Dibromooctafluorobiphenyl	43 %	42 %	42 %	38 %	35 %	150 %	95 %	100 %	100 %
Dibutylchlorendate	74 %	82 %	82 %	81 %	93 %	54 %	73 %	120 %	120 %
Decachlorobiphenyl	72 %	91 %	89 %	70 %	84 %	78 %	95 %	130 %	110 %
Total Organic Carbon	0.86 %						0.74 %		
Percent Solids							74.1 %		

QUALIFIERS:
U - The analyte was not detected at or above the reported result

APPENDIX B. PESTICIDE LAB RESULTS.

CHLORINATED PESTICIDES/PCBs

Location:	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1
Type:	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
Matrix:	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment
Analysis:	sample	MS	MS dup.	sample	sample dil.	MS	MS	MS rerun	MS dil.	MS dup.	MS dup.	MS dup. rerun	MS dup. dil.	method blank
Sample Date:	6/5/91	6/5/91	6/5/91	7/31/91	7/31/91	7/31/91	7/31/91	7/31/91	7/31/91	7/31/91	7/31/91	7/31/91	7/31/91	7/31/91
Time:	0840	0840	0840	0835	0835	0835	0835	0835	0835	0835	0835	0835	0835	0835
Lab Log#:	248556	248556	248556	328474	328474	328474	328474	328474	328474	328474	328474	328474	328474	328474
Lab:	ATI	ATI	ATI	ARI	ARI	ARI	ARI	ARI	ARI	ARI	ARI	ARI	ARI	ARI
Method:	EPA 1618	EPA 1618	EPA 1618	EPA SW846	EPA SW846	EPA SW846	EPA SW846	EPA SW846	EPA SW846	EPA SW846	EPA SW846	EPA SW846	EPA SW846	EPA SW846
Units:	ug/Kg	% recovery	% recovery	ug/Kg	ug/Kg	ug/Kg	% recovery	ug/Kg	ug/Kg	ug/Kg	% recovery	ug/Kg	ug/Kg	ug/Kg
alpha-BHC	0.3 U			0.8 U	8 U	0.4 U		0.4 U	4 U	0.4 U		0.4 U	4 U	0.8 U
beta-BHC	0.3 U			0.8 U	8 U	0.4 U		0.4 U	4 U	0.4 U		0.4 U	4 U	0.8 U
gamma-BHC (Lindane)		96 %	100 %	0.8 U	8 U		94 %				89 %			0.8 U
delta-BHC	0.3 U			1.1 U	11 U	0.6 U		0.6 U	5.5 U	0.6 U		0.6 U	5.5 U	1.1 U
Heptachlor	0.3 U	77 %	79 %	0.8 U	8 U		78 %				72 %			0.8 U
Aldrin	0.3 U	84 %	102 %	0.8 U	8 U		128 %				122 %			0.8 U
Heptachlor Epoxide	0.3 U			0.8 U	8 U	0.4 U		0.4 U	4 U	0.4 U		0.4 U	4 U	0.8 U
Endosulfan I	0.3 U			0.8 U	8 U	0.4 U		0.4 U	4 U	0.4 U		0.4 U	4 U	0.8 U
4,4'-DDE	21			42 X	41	50 X		49 X	60	50 X		52 X	70	1.6 U
Dieldrin		90 %	90 %	1.6 U	16 U		64 %				59 %			1.6 U
Endrin	0.3 U	114 %	123 %	1.6 U	16 U		102 %				100 %			1.6 U
Endosulfan II	0.3 U			1.6 U	16 U	0.8 U		0.8 U	8 U	0.8 U		0.8 U	8 U	1.6 U
4,4'-DDD	4.4			3.0 U	30 U	1.5 U		1.5 U	15 U	1.5 U		1.5 U	15 U	1.6 U
Endrin Aldehyde	0.5 U													
4,4'-DDT	10	51 %	72 %	36 X	36		227 %Q				273 %Q			1.6 U
Endosulfan Sulfate	0.3 U			3.2 U	32 U	1.6 U		1.6 U	16 U	1.6 U		1.6 U	16 U	3.2 U
Endrin Ketone	0.5 U			2.2 U	22 U	1.1 U		1.1 U	11 U	1.1 U		1.1 U	11 U	2.2 U
Methoxychlor	0.5 U			3.2 U	32 U	1.6 U		1.6 U	16 U	1.6 U		1.6 U	16 U	3.2 U
Chlordane														
Toxaphene	10 U			110 U	1100 U	55 U		55 U	550 U	55 U		55 U	550 U	110 U
Aroclor-1242/1016				16 U	160 U	8 U		8 U	80 U	8 U		8 U	80 U	16 U
Aroclor-1221				16 U	160 U	8 U		8 U	80 U	8 U		8 U	80 U	16 U
Aroclor-1248				16 U	160 U	8 U		8 U	80 U	8 U		8 U	80 U	16 U
Aroclor-1254				16 U	160 U	8 U		8 U	80 U	8 U		8 U	80 U	16 U
Aroclor-1260				16 U	160 U	8 U		8 U	80 U	8 U		8 U	80 U	16 U
alpha-Chlordane	0.3 U			1.1 U	11 U	0.6 U		5.5 U	5.5 U	0.6 U		5.5 U	5.5 U	1.1 U
gamma-Chlordane	0.3 U			1.1 U	11 U	0.6 U		0.6 U	5.5 U	0.6 U		0.6 U	5.5 U	1.1 U
Total PCBs	3 U													
surrogates and % recovery:														
4,4-Dibromooctafluorobiphenyl				81 %	63 %	86 %		69 %	72 %	83 %		68 %	75 %	68 %
Dibutylchlorendate				87 %	75 %	90 %		73 %	85 %	84 %		71 %	89 %	76 %
Total Organic Carbon	1.5 %			1.83 %										
Percent Solids	67 %			66 %										

QUALIFIERS:
U - The analyte was not detected at or above the reported result
UJ - The analyte was not detected at or above the reported estimated result.
X - The concentration of the analyte exceeded the calibration range, and a dilution should be performed.
Q - Surrogate recovery outside of QA limits. In this case, this is an anomaly because the native amount of 4,4'-DDT was nearly 10 times the amount added as a spike.

APPENDIX B. PESTICIDE LAB RESULTS.

ORGANOPHOSPHORUS PESTICIDES

Location:	D1	D1	D1	D1	D1	D1	D1	D1	sed basin	sed basin
Type:	grab	grab	grab	grab	grab	composite	composite	composite	grab	grab
Matrix:	sediment	sediment	sediment	sediment	sediment	water–total	water–total	water–total	sediment	sediment
Analysis:	sample	MS	MS dup.	sample	method blank	sample	blank 1	blank 2	sample	blank
Date:	6/5/91	6/5/91	6/5/91	7/31/91	7/31/91	6/8–9/92	6/8–9/92	6/8–9/92	8/4/92	8/4/92
Time:	0840	0840	0840	0835	0835	1300/1000	1300/1000	1300/1000	1130	1130
Lab Log#:	248556	248556	248556	328474	328474	248861	248861	248861	328763	328763
Lab:	ATI	ATI	ATI	ARI	ARI	Manchester	Manchester	Manchester	Manchester	Manchester
Method:	EPA 1618	EPA 1618	EPA 1618	EPA SW846	EPA SW846	EPA 1618	EPA 1618	EPA 1618	EPA SW846	8140(modified)
Units:	ug/Kg	% recovery	% recovery	ug/Kg	ug/Kg	ug/L	ug/L	ug/L	ug/Kg	ug/Kg
Abate (Temephos)						1.718 U	1.718 U	1.718 U		
Atrazine				6.0 UJ	6.0 UJ					
Azinphos Ethyl						0.458 U	0.458 U	0.458 U	0.270 U	0.270 U
Azinphos Methyl (Guthion)	20 U	98 %	96 %			0.347 UJ	0.347 UJ	0.347 UJ	0.300 U	0.300 U
Bolstar (Sulprofos)						0.121 U	0.121 U	0.121 U		
Butifos (DEF)						0.267 U	0.267 U	0.267 U		
Carbophenothion						0.261 U	0.261 U	0.261 U	0.170 U	0.170 U
Chlorpyrifos (Dursban)	3 U			2.0 UJ	2.0 UJ	0.102 U	0.102 U	0.102 U	0.120 U	0.120 U
Coumaphos	3 U			3.0 UJ	3.0 UJ	0.248 U	0.248 U	0.248 U	0.200 UJ	0.200 UJ
Demeton–A	2 U									
Demeton–B	3 U									
Demeton–O						0.106 U	0.106 U	0.106 U		
Demeton–S						0.106 U	0.106 U	0.106 U		
Demeton (Systox)				4.0 UJ	4.0 UJ					
Diazinon (Spectracide)	3 U	88 %	85 %	0.36 J	0.8 UJ	0.161 U	0.161 U	0.161 U	0.130 U	0.130 U
Dichlorvos (DDVP)	3 U			0.3 UJ	0.3 UJ	0.153 U	0.153 U	0.153 U	0.130 U	0.130 U
Dimethoate	3 U					0.191 U	0.191 U	0.191 U	0.130 U	0.130 U
Dioxathion						0.324 U	0.324 U	0.324 U	0.130 U	0.130 U
Disulfoton (Di–Syston)	2 U	93 %	91 %	10 UJ	10 UJ	0.121 U	0.121 U	0.121 U	0.100 U	0.100 U
EPN	2 U								0.170 U	0.170 U
EPTC (Eptam)				2.7 UJ	2.7 UJ					
Ethion	2 U					0.140 U	0.140 U	0.140 U	0.120 U	0.120 U
Ethoprop (Mocap)	2 U			2.0 UJ	2.0 UJ	0.164 U	0.164 U	0.164 U	0.130 U	0.130 U
Fenamiphos						0.286 U	0.286 U	0.286 U		
Fenitrothion						0.131 U	0.131 U	0.131 U		
Fensulfothion (Desanit)	3 U			2.0 UJ	2.0 UJ	0.305 U	0.305 U	0.305 U		
Fenthion (Baytex)	2 U			2.0 UJ	2.0 UJ	0.176 U	0.176 U	0.176 U	0.120 U	0.120 U
Fonophos						0.103 U	0.103 U	0.103 U	0.100 U	0.100 U
Hexazinon (Velpar)				6.0 UJ	6.0 UJ					
Imidan (Phosmet)						0.207 UJ	0.207 UJ	0.207 UJ	0.180 U	0.180 U
Malathion	2 U	92 %	86 %			0.185 U	0.185 U	0.185 U	0.130 U	0.130 U
Merphos 1	2 U					0.308 U	0.308 U	0.308 U		
Merphos 2	3 U					0.308 U	0.308 U	0.308 U		
Methyl Chlorpyrifos	2 U					0.082 U	0.082 U	0.082 U		
Methyl Paraoxon						0.344 UJ	0.344 UJ	0.344 UJ		
Methyl Parathion	2 U	88 %	86 %			0.146 U	0.146 U	0.146 U	0.120 U	0.120 U
Mevinphos (Phosdrin)	3 U			0.4 UJ	0.4 UJ	0.191 U	0.191 U	0.191 U	0.170 UJ	0.170 UJ
Monocrotophos						1.336 UJ	1.336 UJ	1.336 UJ		
Naled (Dibrom)	20 U			20 UJ	20 UJ					
Parathion	2 U	105 %	96 %			0.148 U	0.148 U	0.148 U	0.130 U	0.130 U
Parathion Methyl				2.0 UJ	2.0 UJ					
Phorate	30 U			3.0 UJ	3.0 UJ	0.100 U	0.100 U	0.100 U	0.120 U	0.120 U
Phosphamidan						0.458 U	0.458 U	0.458 U		
Prometon				10.0 UJ	10.0 UJ					
Pronamide				60 UJ	60 UJ					
Propetamphos						0.382 U	0.382 U	0.382 U		
Ronnel (Fenchlorphos)	2 U			2.0 UJ	2.0 UJ	0.104 U	0.104 U	0.104 U	0.120 U	0.120 U
Simazine				20 UJ	20 UJ					
Sulfotepp	0.8 U					0.114 U	0.114 U	0.114 U		
Sulprophos	2 U									
Tebuthiuron				9.0 UJ	9.0 UJ					
Tetrachlorvinphos (Gardona)	3 U			2.0 UJ	2.0 UJ	0.382 U	0.382 U	0.382 U		
Tetraethyl Pyrophosphate						0.103 U	0.103 U	0.103 U		
Tokuthion	3 U									
Trichloronate	2 U									
Trifluralin (Treflan)				14 UJ	14 UJ					
surrogates and % recovery:										
Triphenyl Phosphates (SS)						76 %	62 %	65 %	101 %	76 %
Alachlor				28 %	29 %					
Total Organic Carbon	1.5 %			1.83 %		0.86 %			0.74 %	
Percent Solids	67 %			66 %					74.1 %	

QUALIFIERS:

U – The analyte was not detected at or above the reported result.

UJ – The analyte was not detected at or above the reported estimated result.

result is an estimate.

pestdat1.wk1 a65..w147

APPENDIX B. PESTICIDE LAB RESULTS.

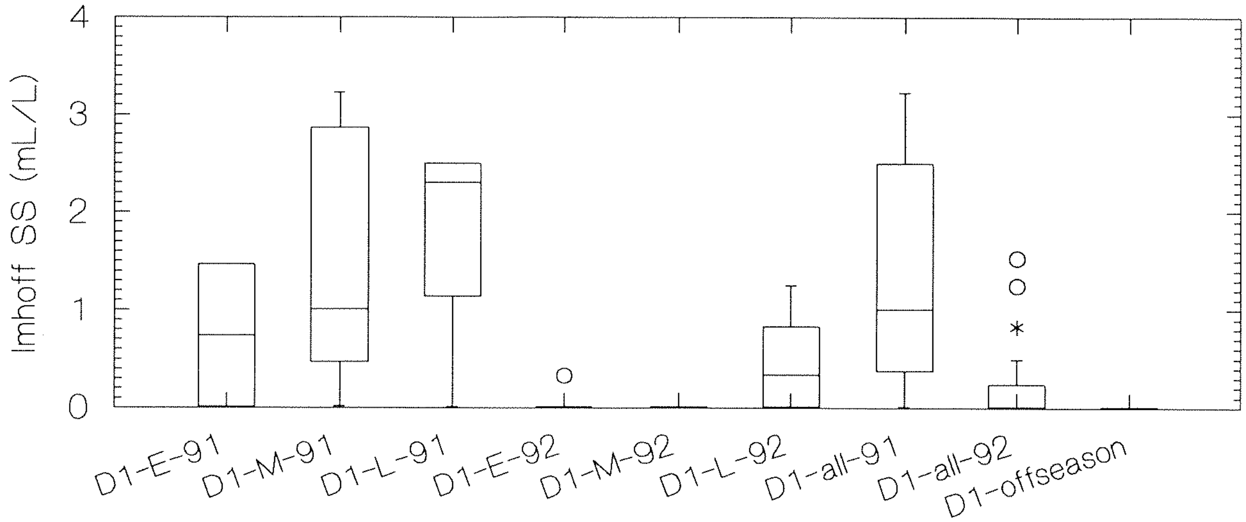
HERBICIDES

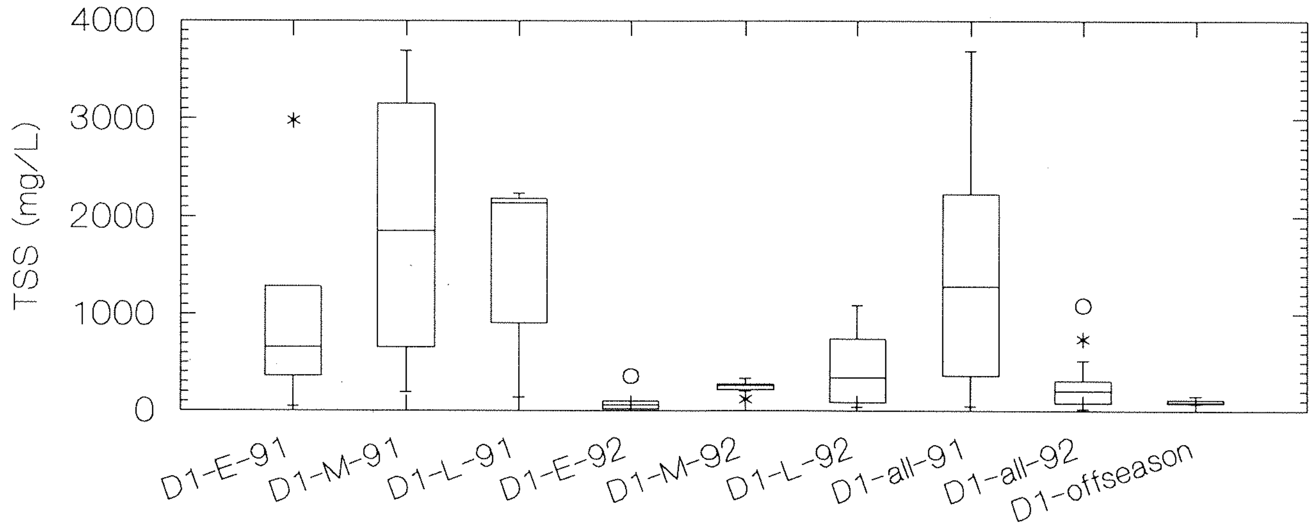
Location:	D1	D1	sed basin	sed basin
Type:	composite	composite	grab	grab
Matrix:	water-total	water-total	sediment	sediment
Analysis:	sample	blank 1	sample	blank 1
Date:	6/8-9/92	6/8-9/92	8/4/92	8/4/92
Time:	1300/1000	1300/1000	1130	1130
Lab Log#:	248861	248861	328763	328763
Lab:	Manchester	Manchester	Manchester	Manchester
Method:	EPA 515.1	EPA 515.1	EPA SW-846 8150(modified)	
Units:	ug/L	ug/L	ug/Kg	ug/Kg
2,3,4,5-Tetrachlorophenol	0.013 UJ	0.013 U	7 U	7 UJ
2,4,5-T	0.017 UJ	0.017 U	15 U	15 UJ
2,4,5-TB	0.017 UJ	0.017 U	15 U	15 UJ
2,4,5-TP (Silvex)	0.017 UJ	0.017 U	15 U	15 UJ
2,4,5-Trichlorophenol	0.043 UJ	0.043 U	10 U	10 UJ
2,4,6-Trichlorophenol	0.022 UJ	0.022 U	10 U	10 UJ
2,4-D	0.032 J	0.035 U	30 U	30 UJ
2,4-DB	0.070 UJ	0.070 U	60 U	60 UJ
Bromoxynil	0.017 UJ	0.017 U	15 U	15 UJ
Dacthal (DCPA)	0.017 UJ	0.017 U	15 U	15 UJ
Dalapon (DPA)	0.087 UJ	0.087 U	40 U	40 UJ
Dicamba	0.017 UJ	0.017 U	15 U	15 UJ
Dichlorprop	0.035 UJ	0.035 U	30 U	30 UJ
Dinoseb	0.017 UJ	0.017 U	15 UJ	15 UJ
Ioxynil	0.026 UJ	0.026 U	15 U	15 UJ
MCPA	0.87 UJ	0.87 U	2000 U	2000 UJ
MCPP	0.87 UJ	0.87 U	2000 U	2000 UJ
Pentachlorophenol	0.009 UJ	0.009 U	7 U	7 UJ
Picloram	0.017 UJ	0.017 U	22 U	22 UJ
surrogate and % recovery				
2,4,6-Tribromophenyl	20 %	96 %	36 %	34 %
Total Organic Carbon	0.86 %		0.74 %	
Percent Solids			74.1 %	

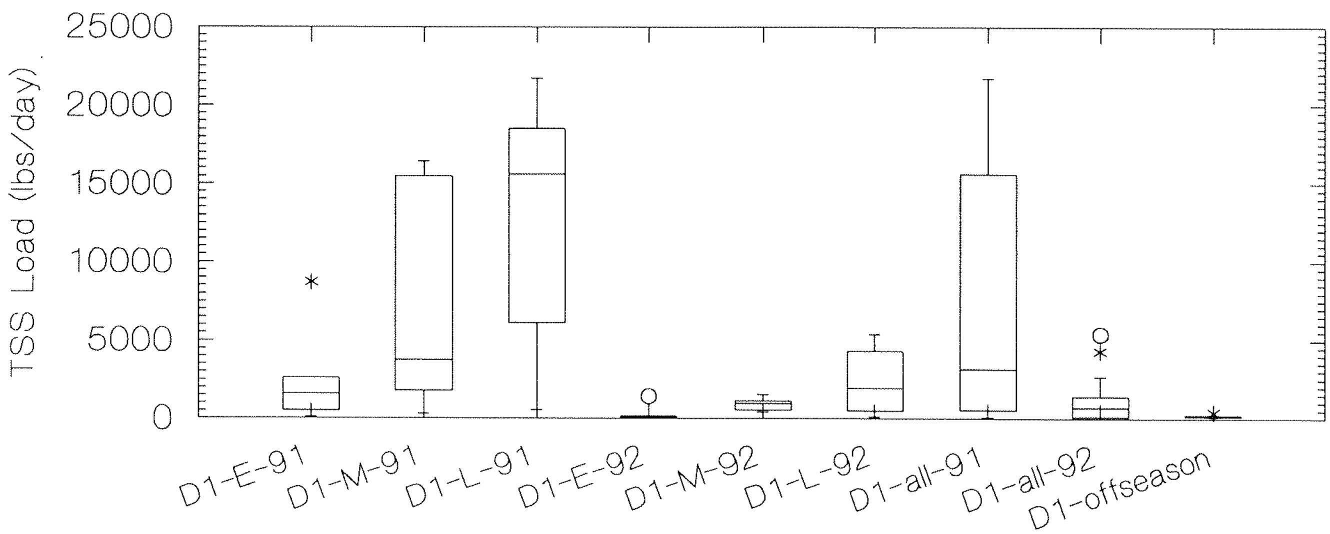
QUALIFIERS:
U – The analyte was not detected at or above the reported result
J – The analyte was positively identified. The associated numerical result is an estimate.
UJ – The analyte was not detected at or above the reported estimated result.

pestdat1.wk1 a152..n196

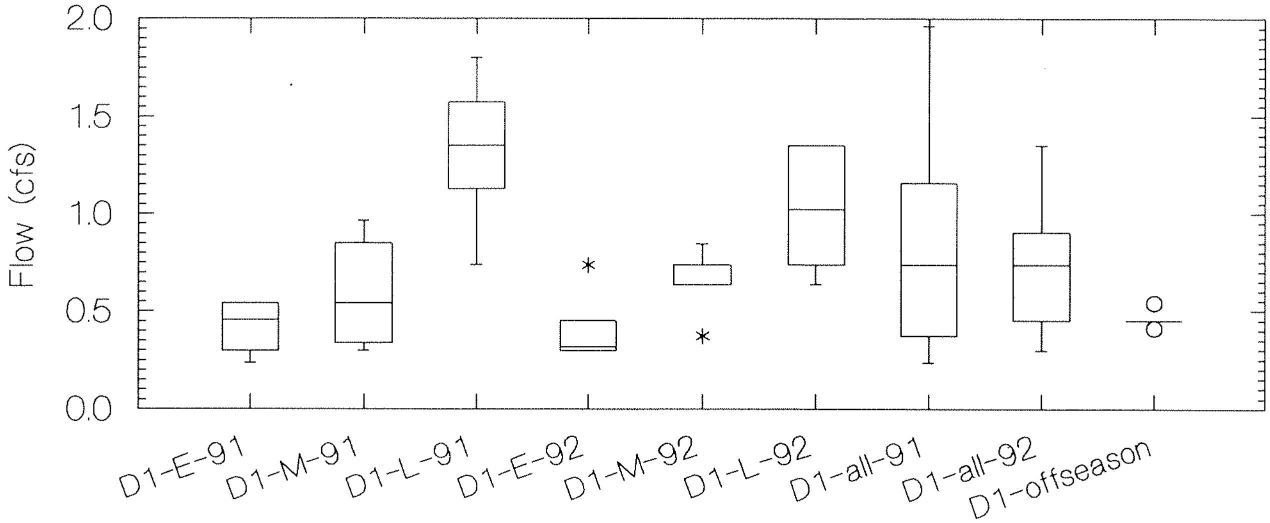
Appendix C. Boxplots by Station and Period.

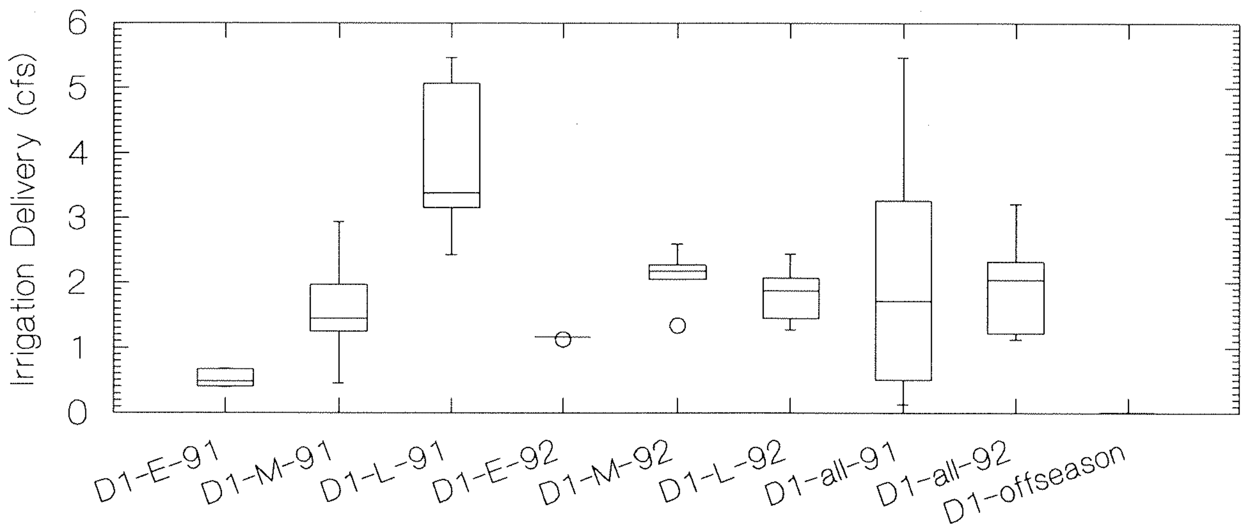


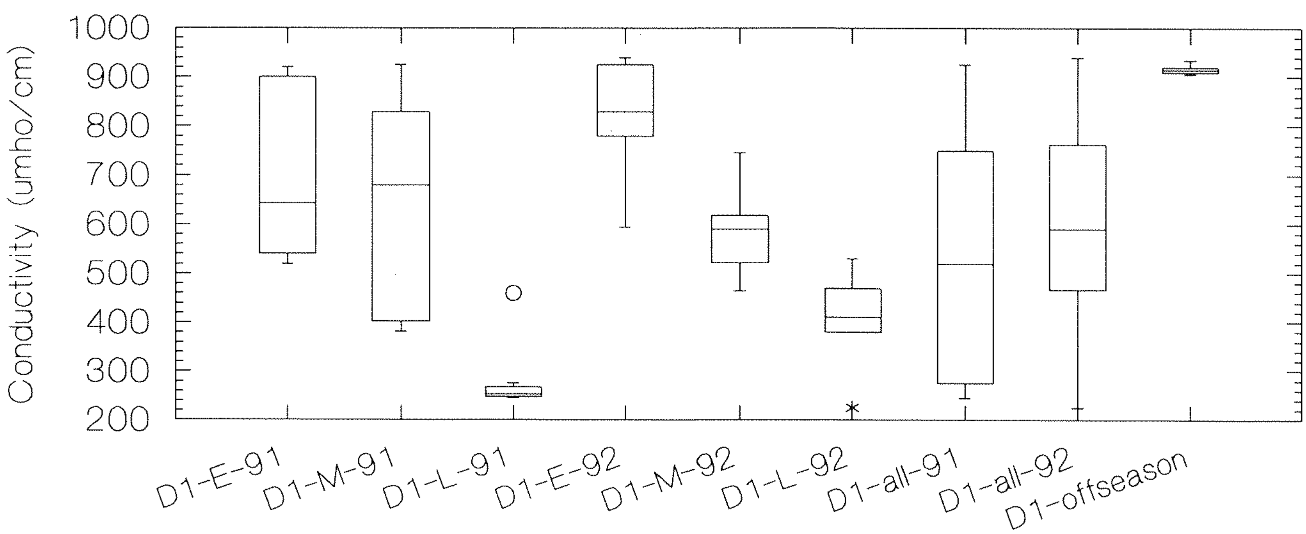




Appendix C. Boxplots by Station and Period.







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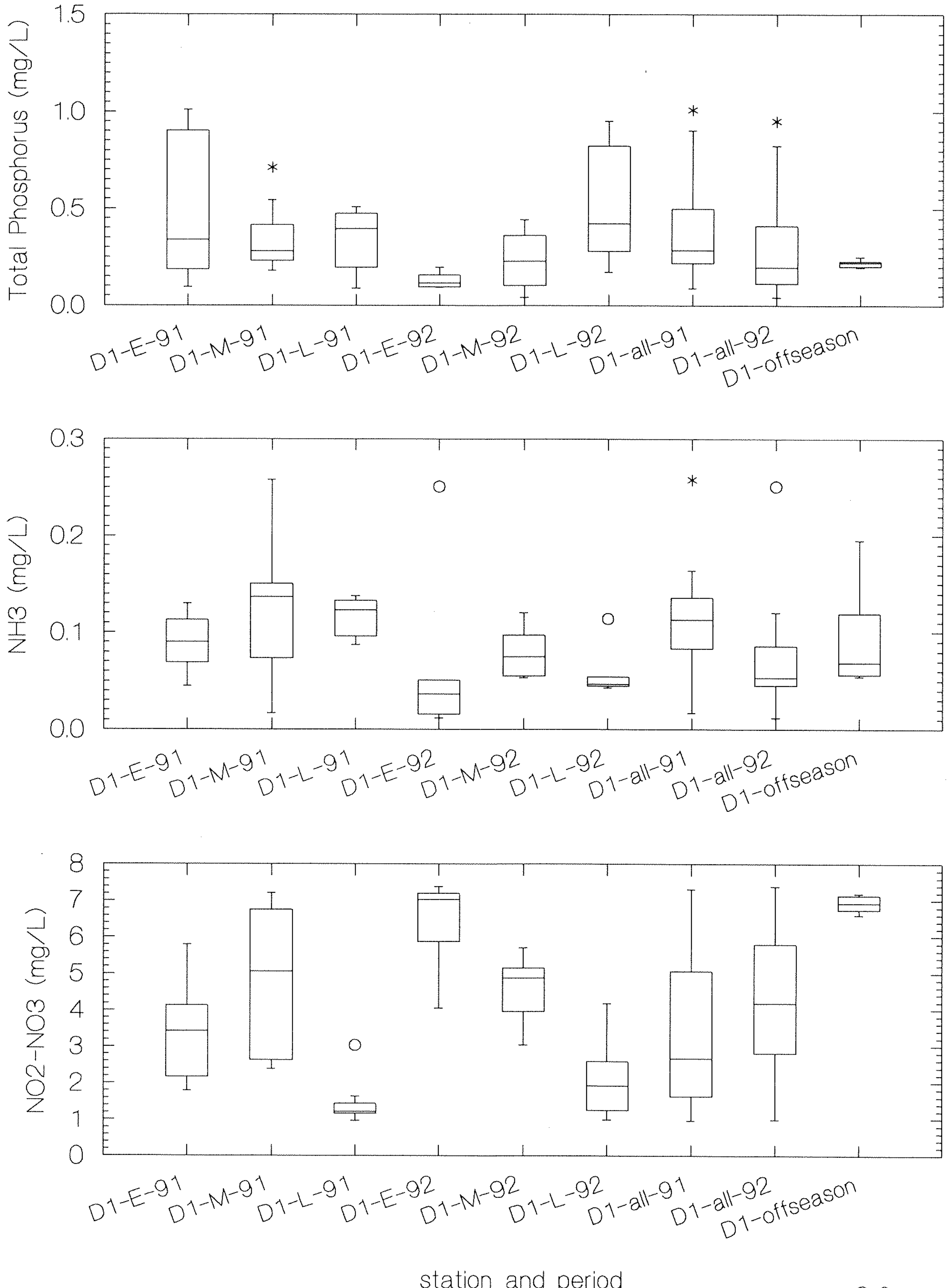

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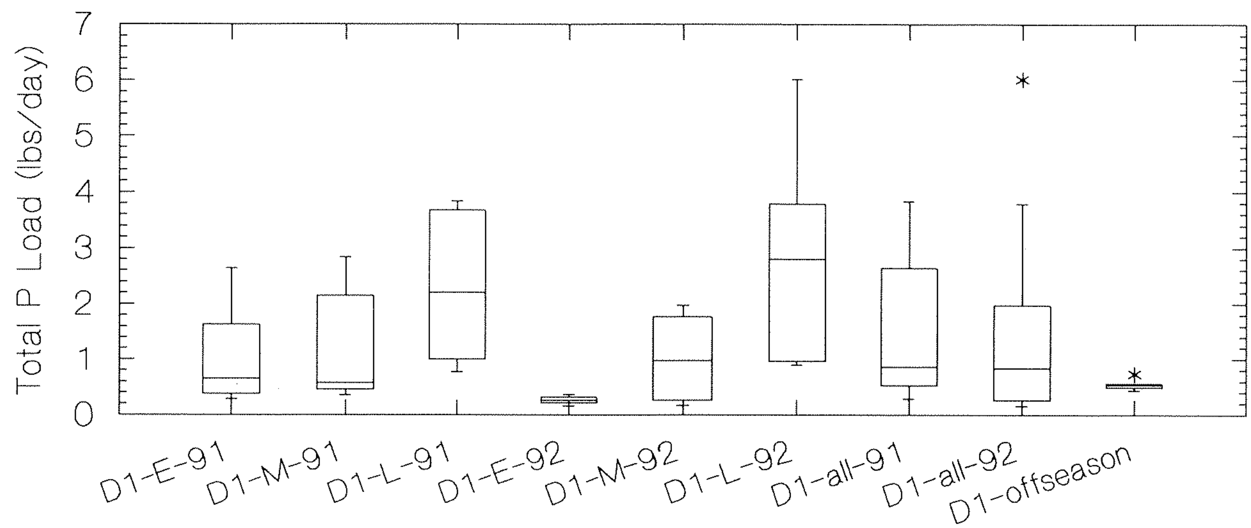

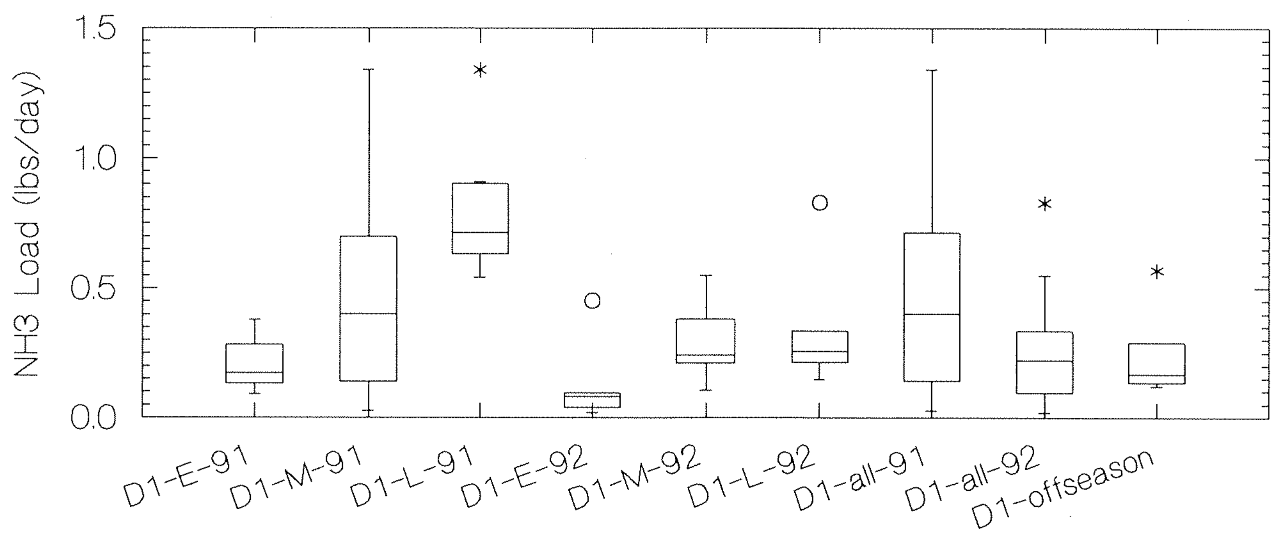

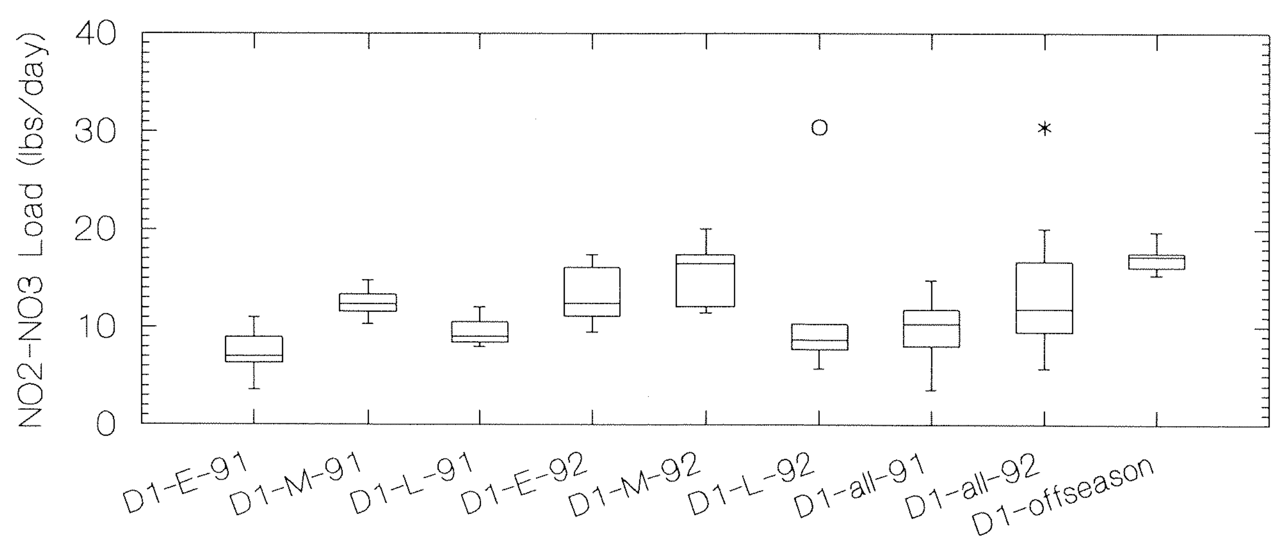

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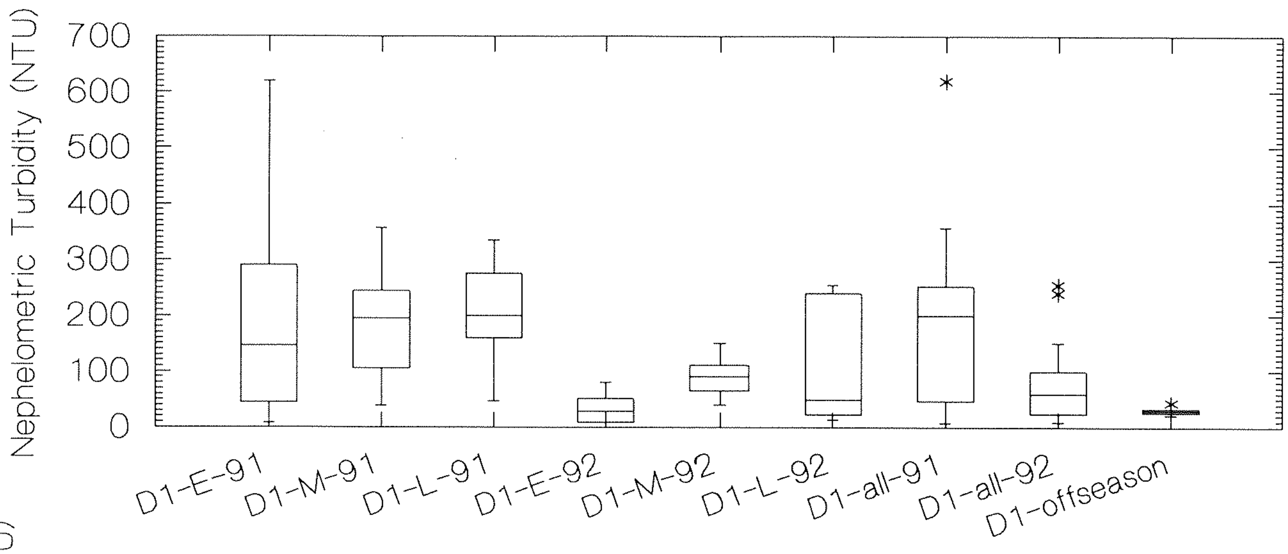

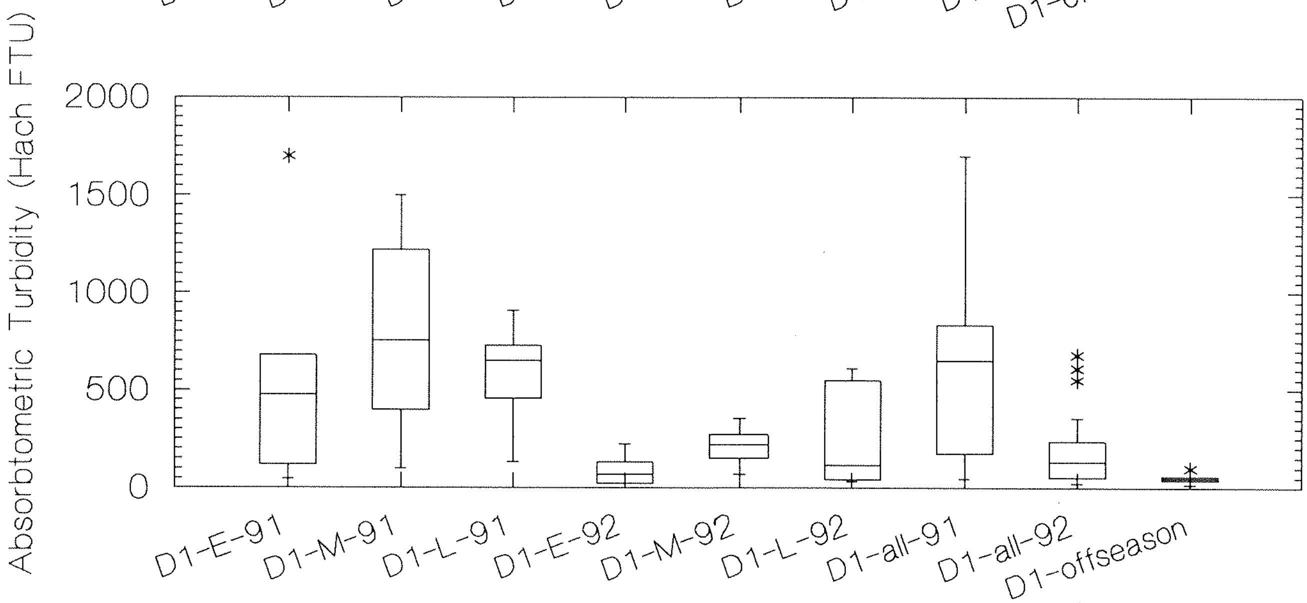

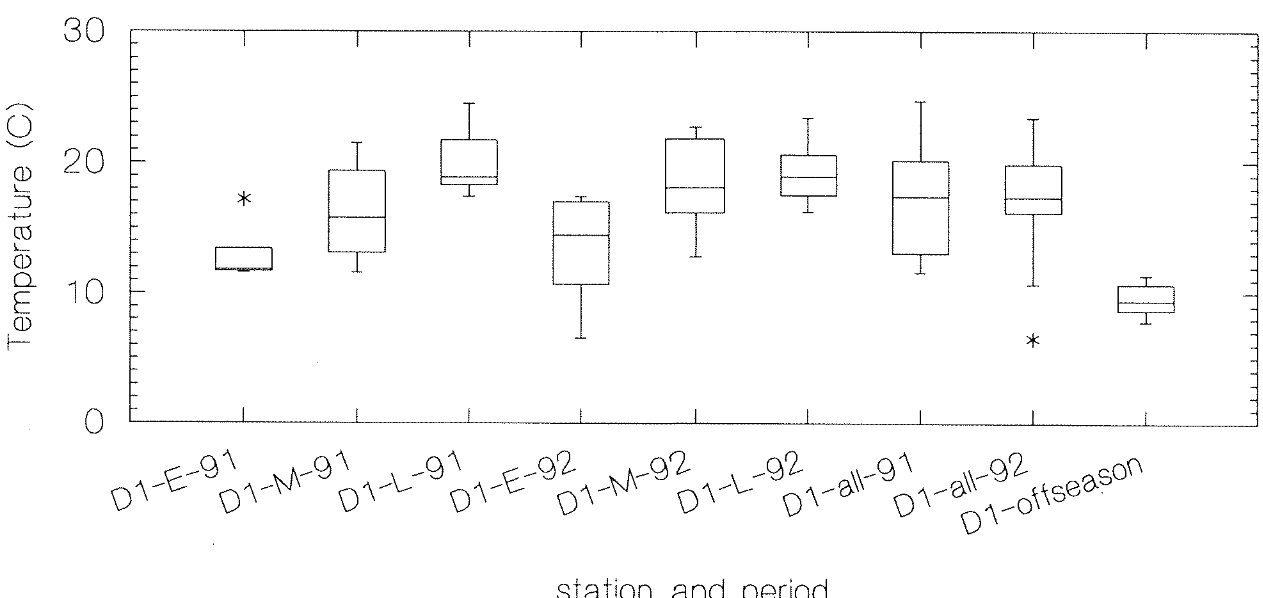

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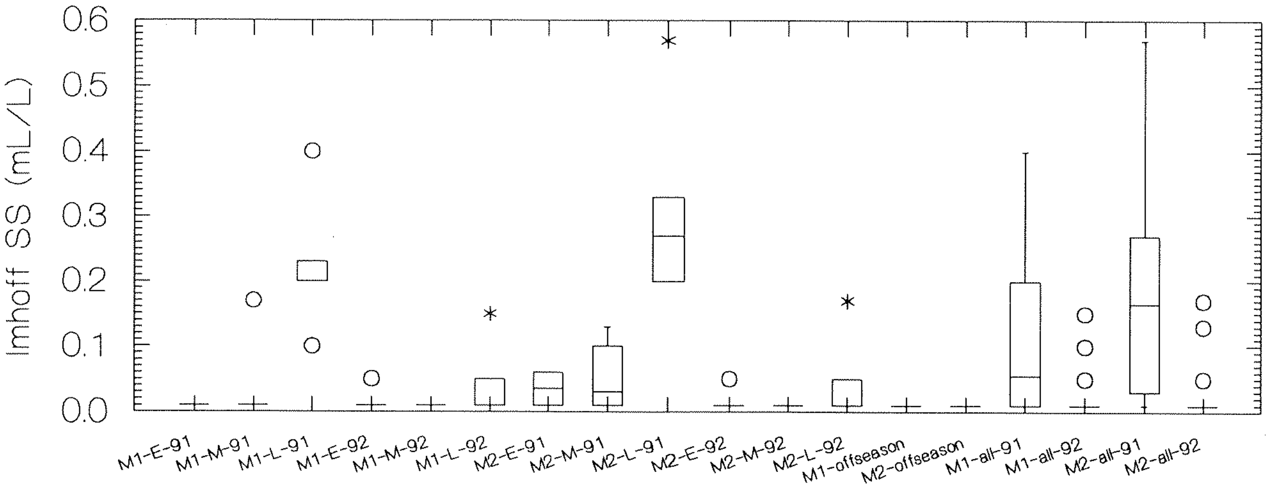

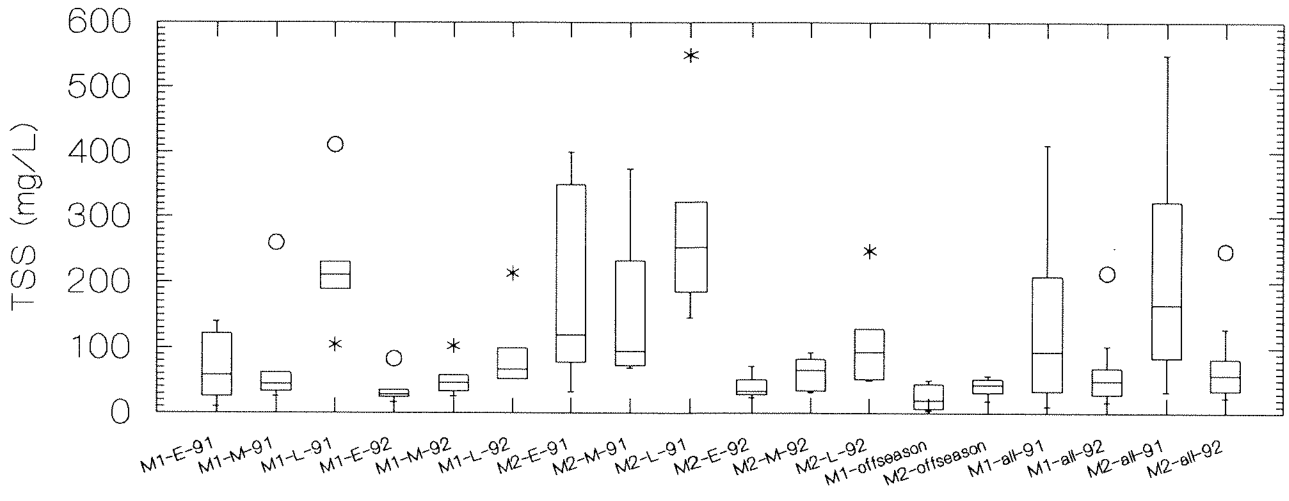

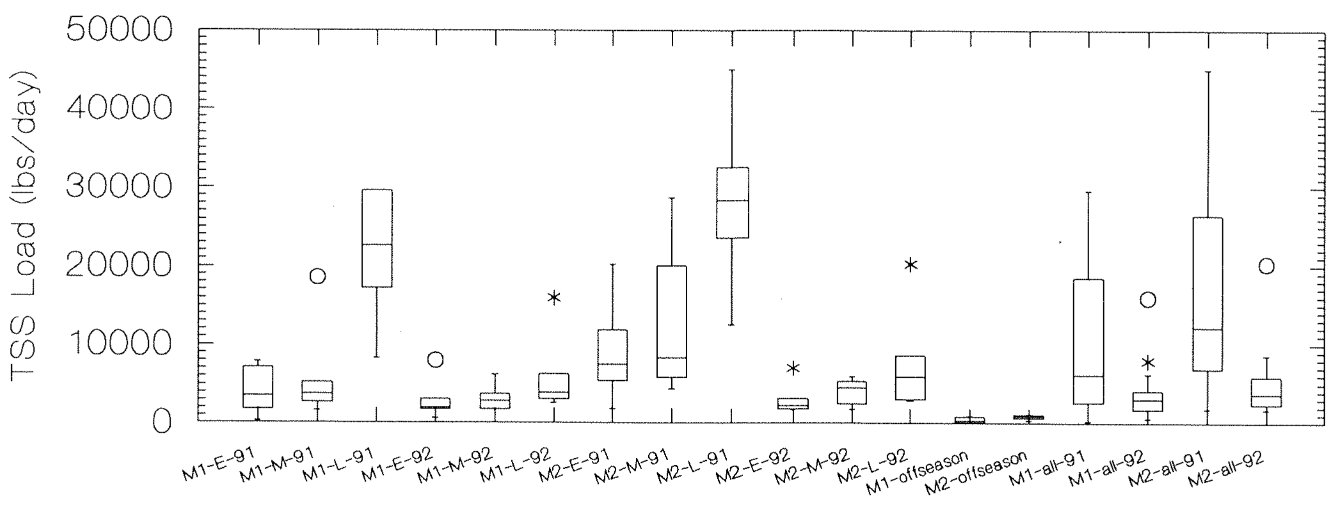

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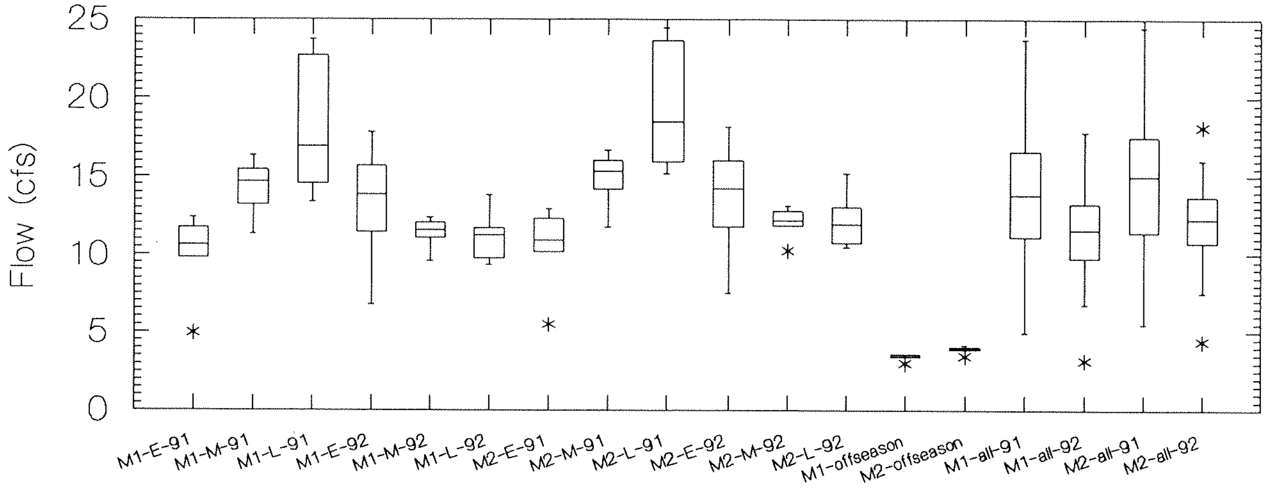
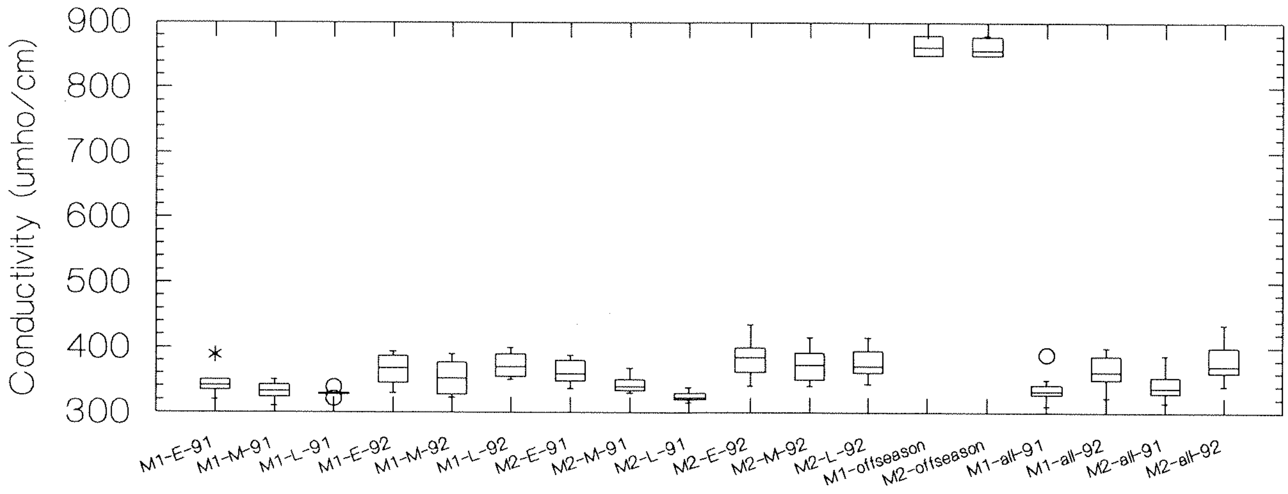
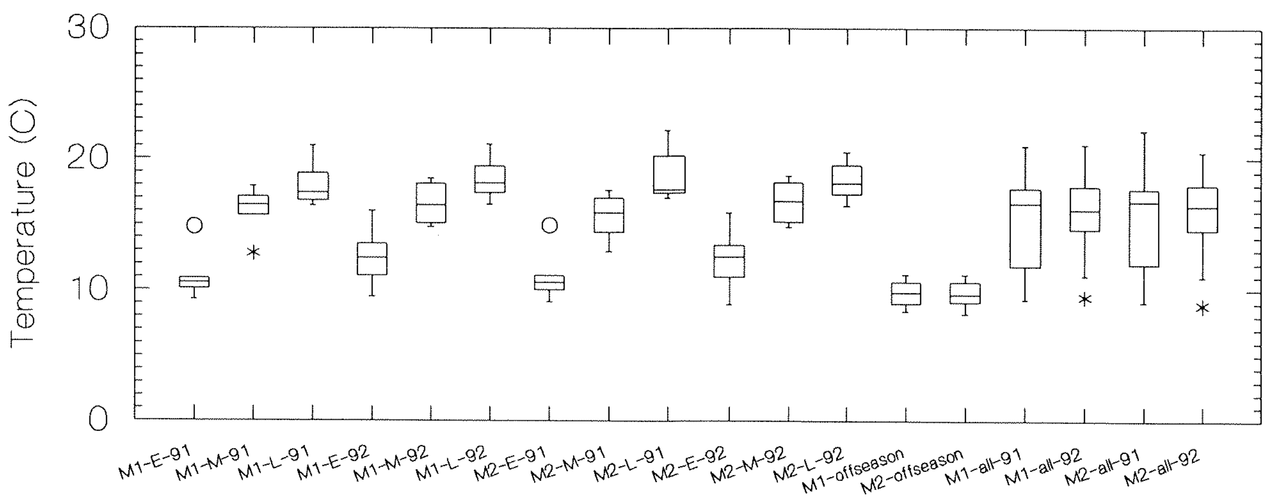
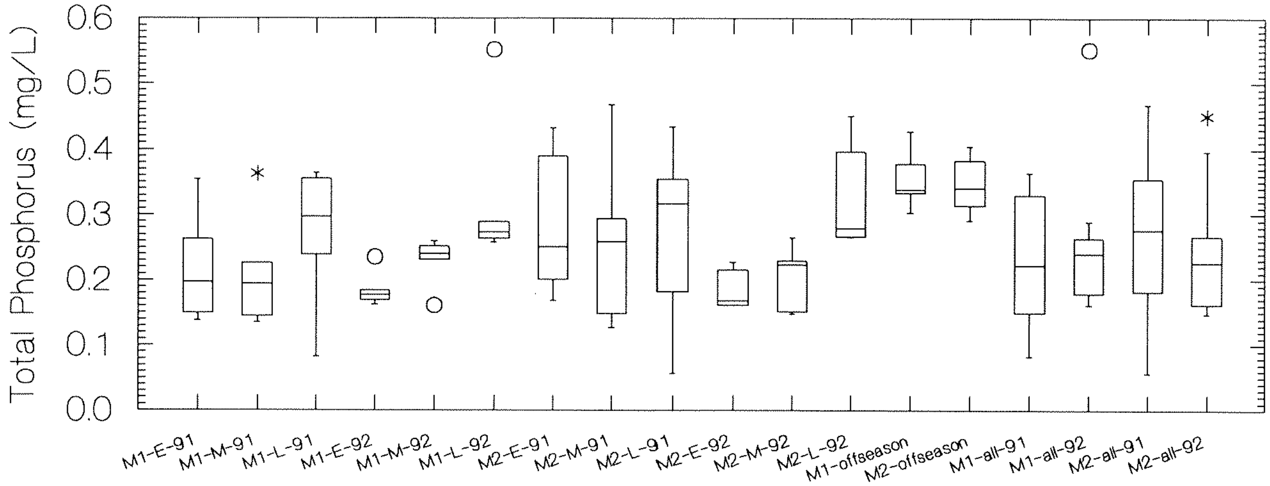


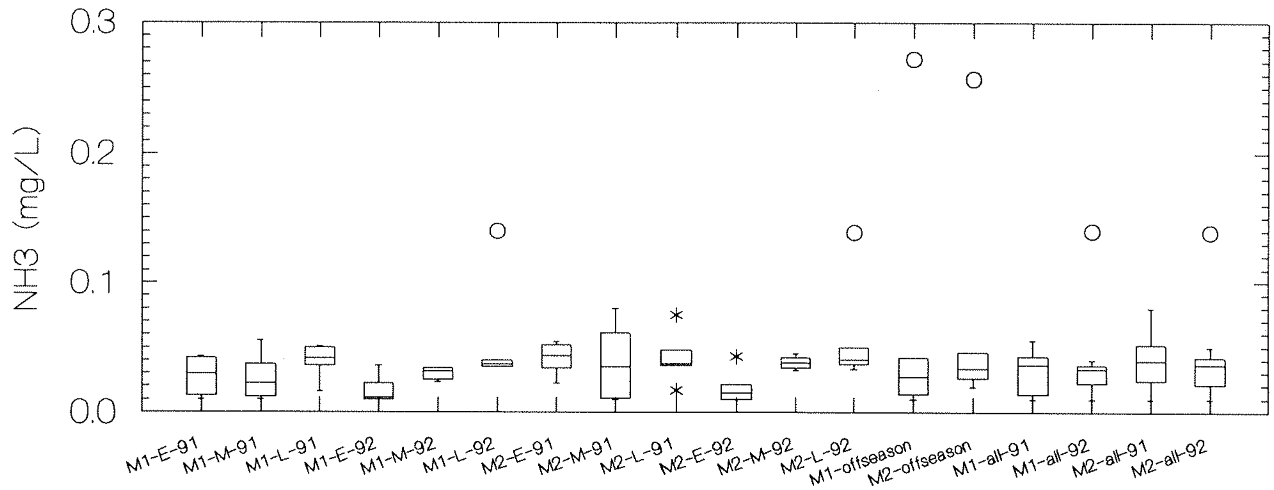


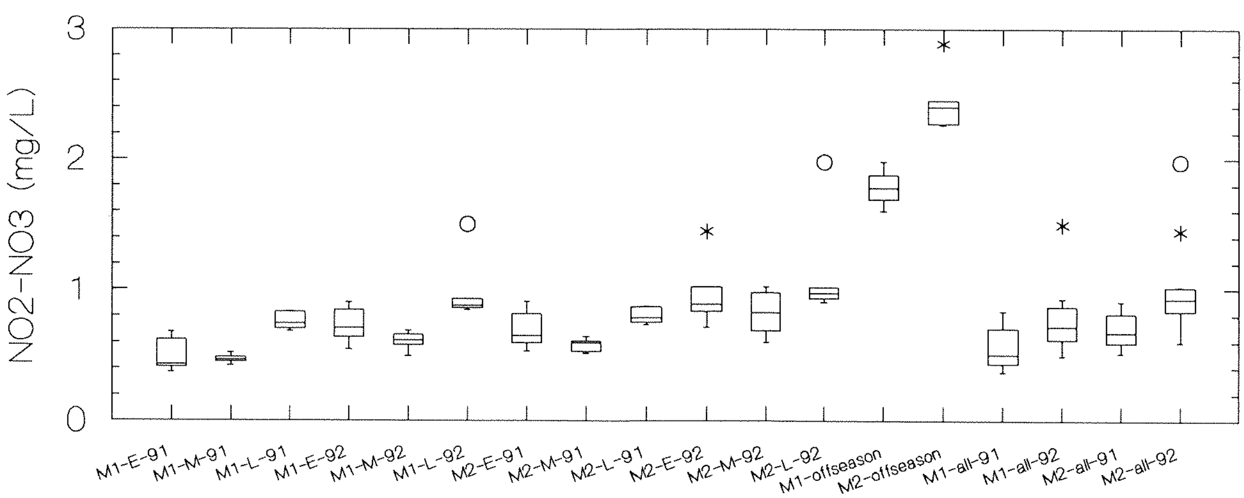


station and period

Appendix C. Boxplots by Station and Period.







station and period

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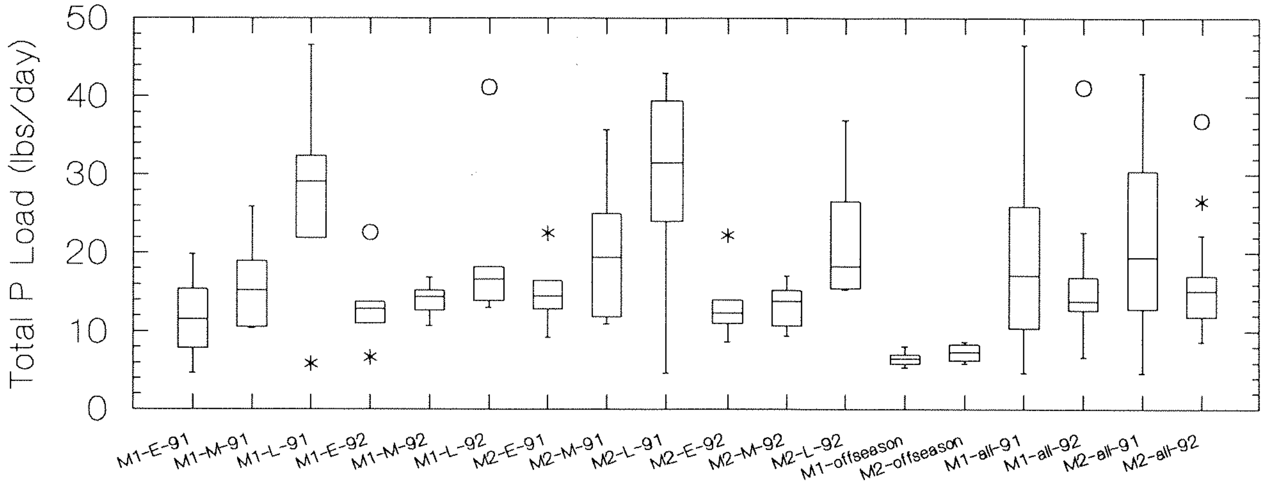
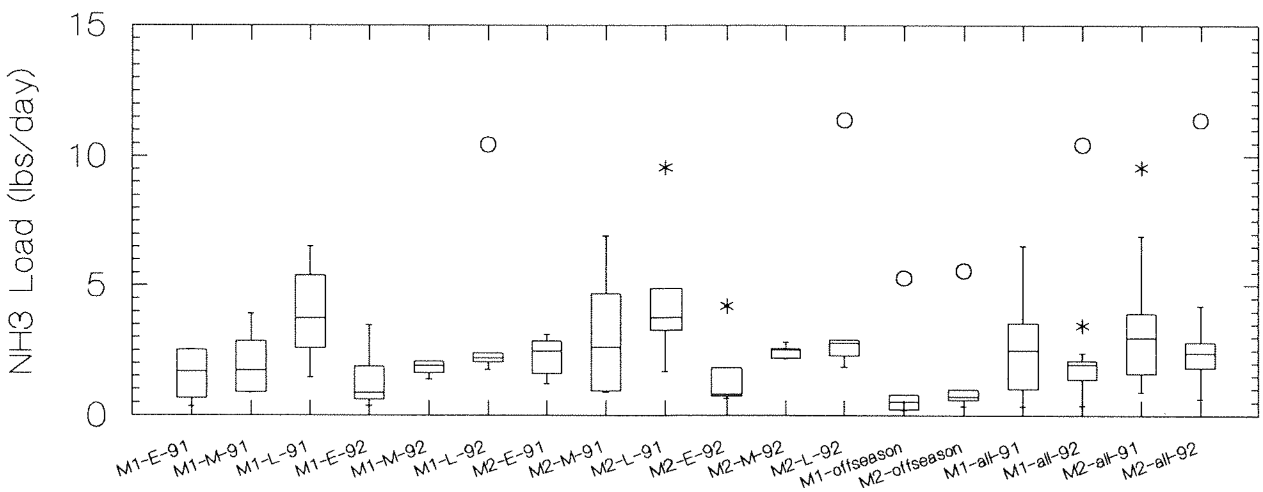
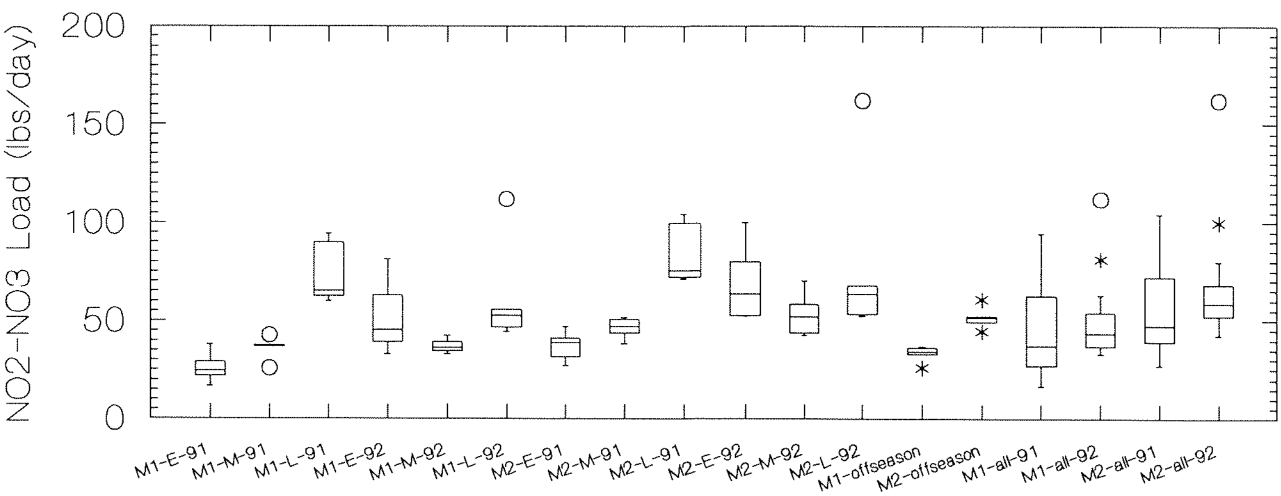
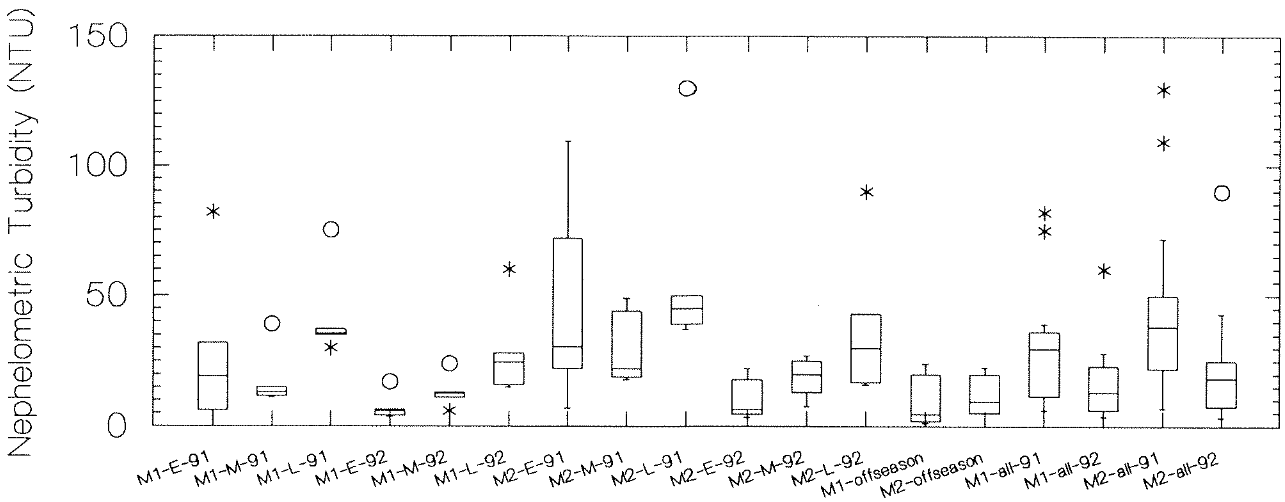
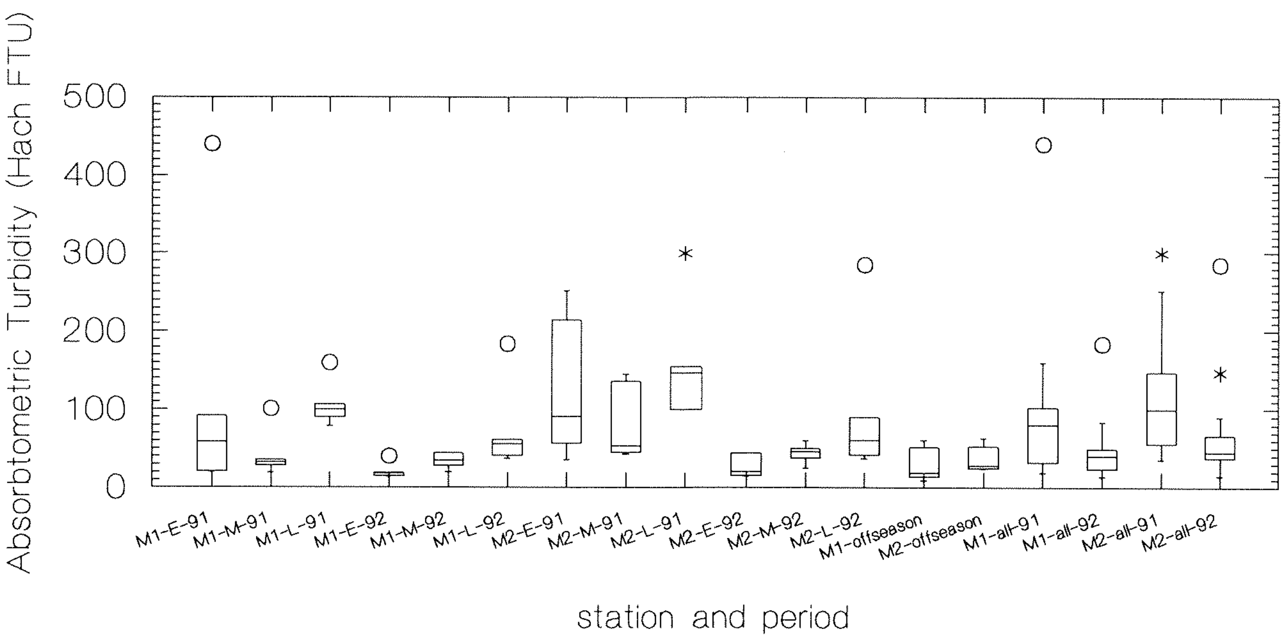




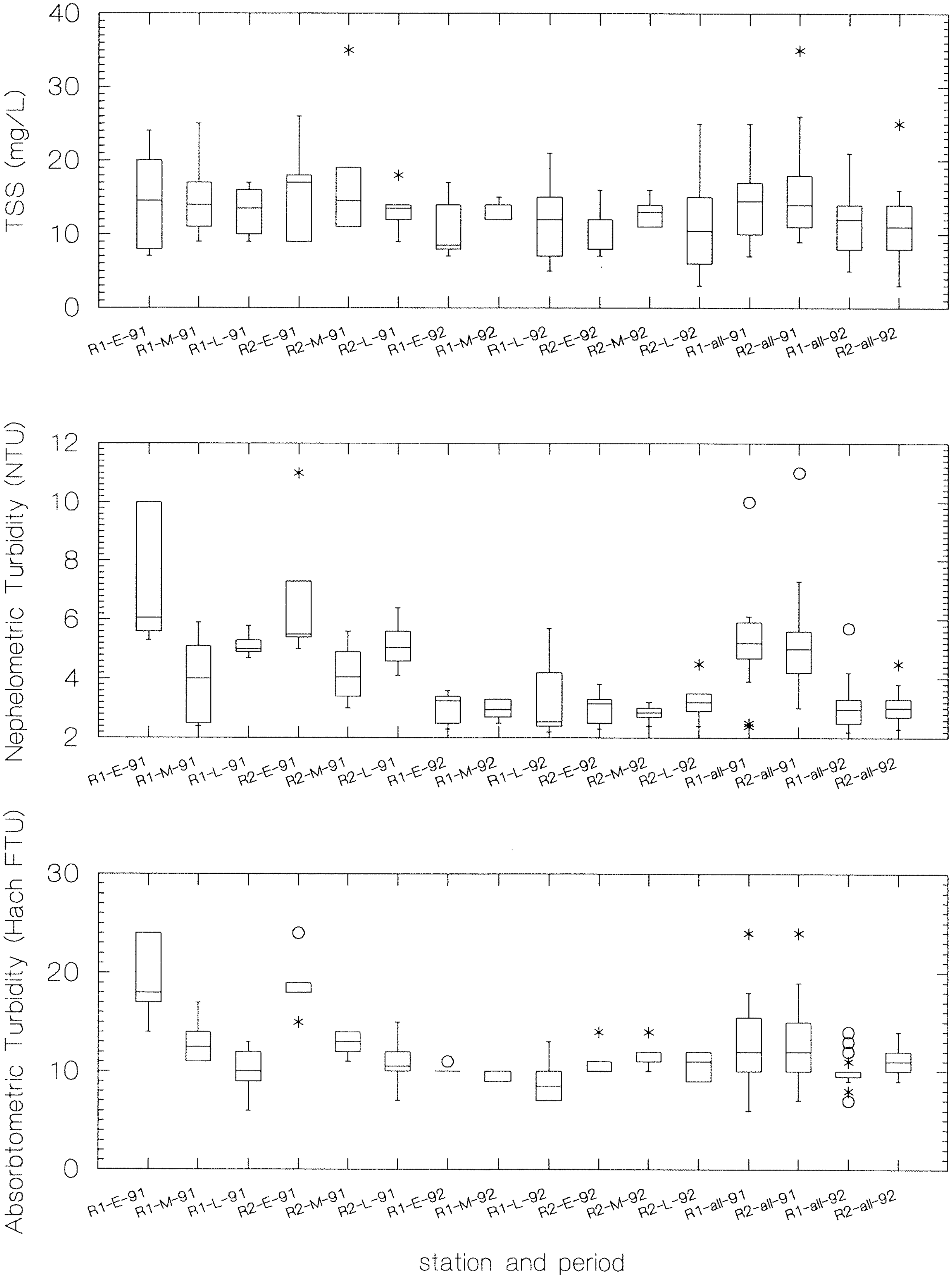


Appendix C. Boxplots by Station and Period.

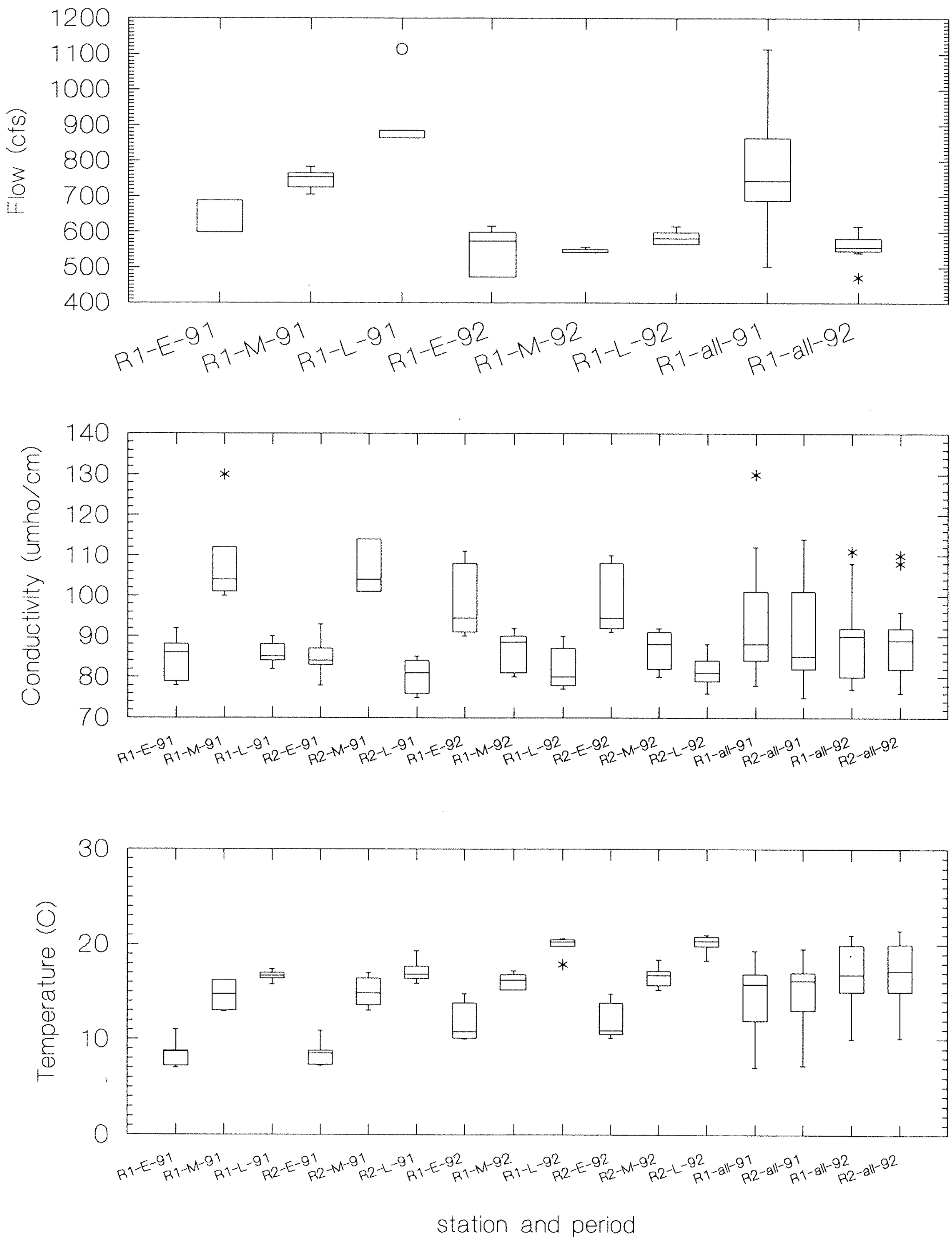




Appendix C. Boxplots by Station and Period.



Appendix C. Boxplots by Station and Period.



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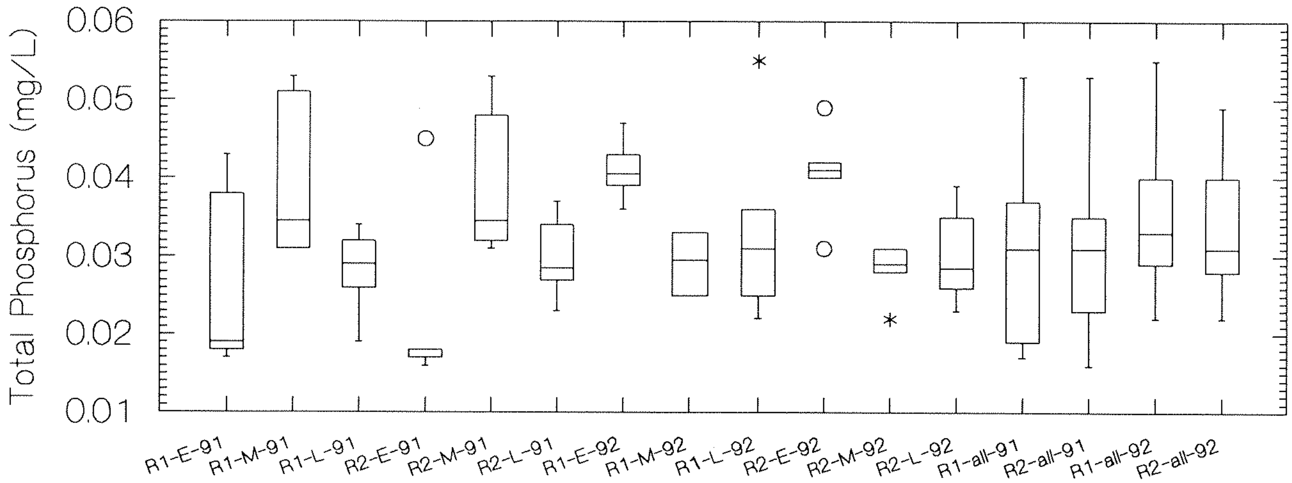

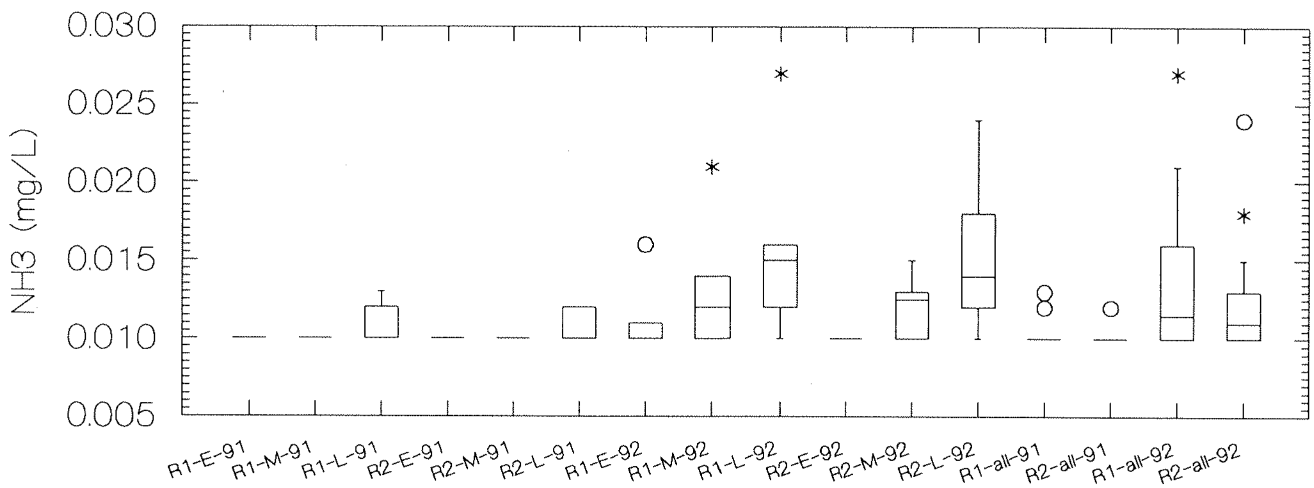

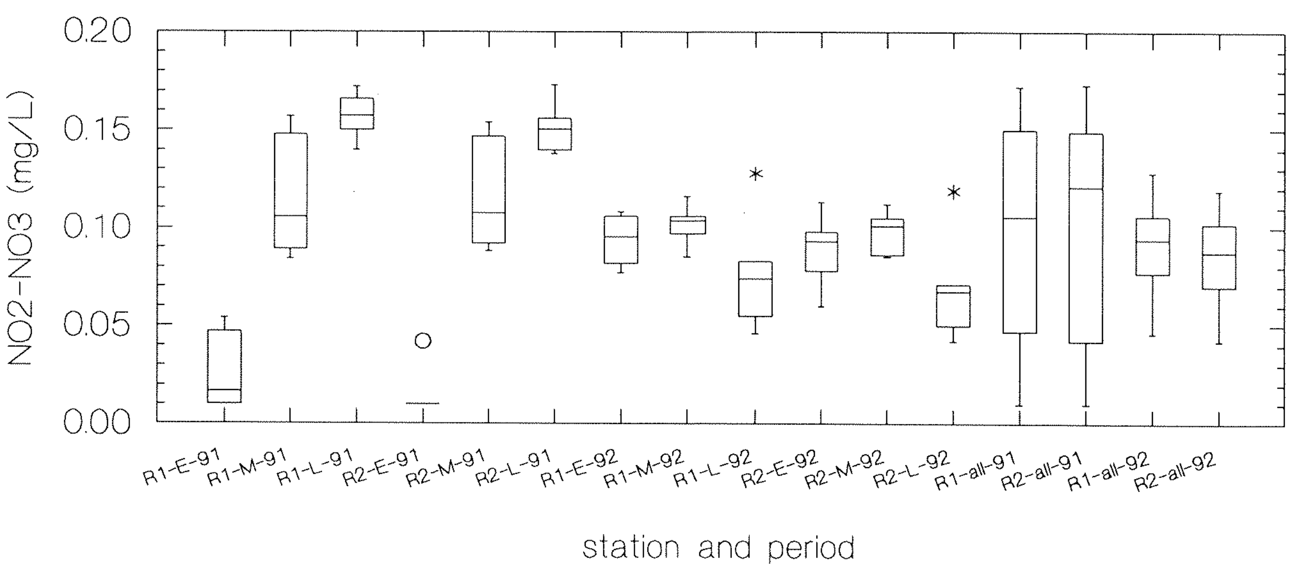

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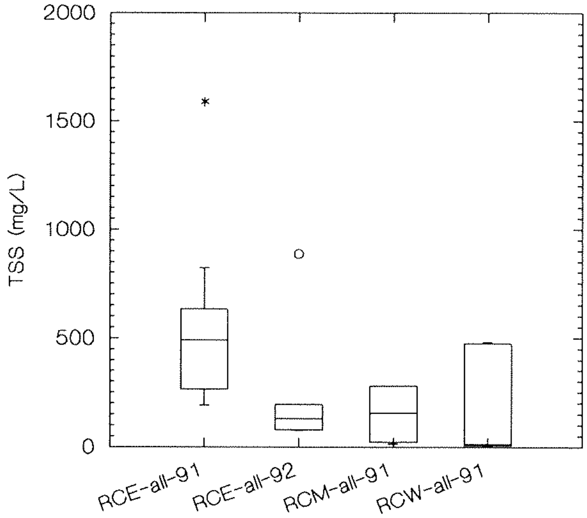

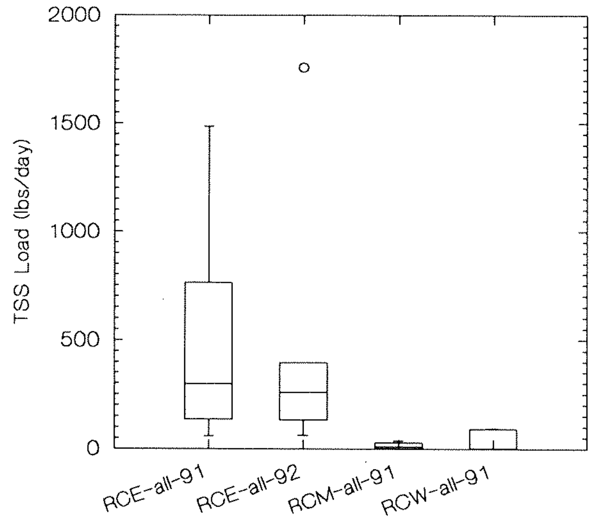

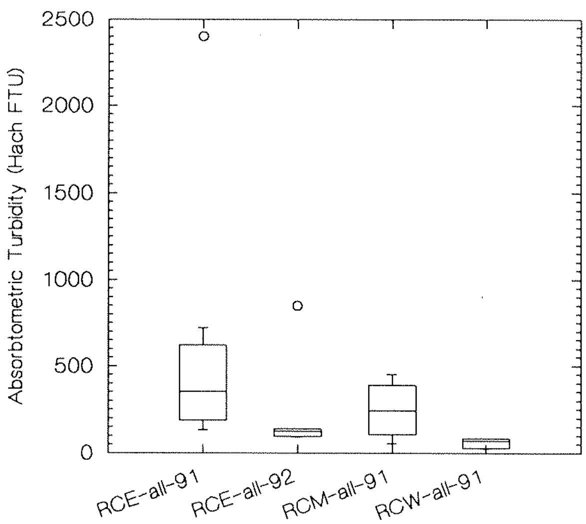

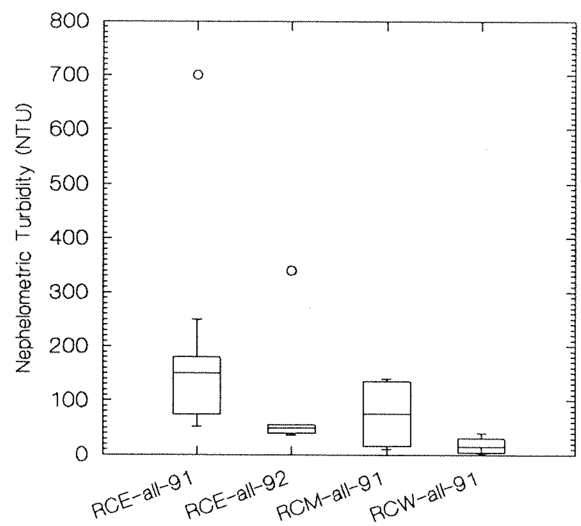

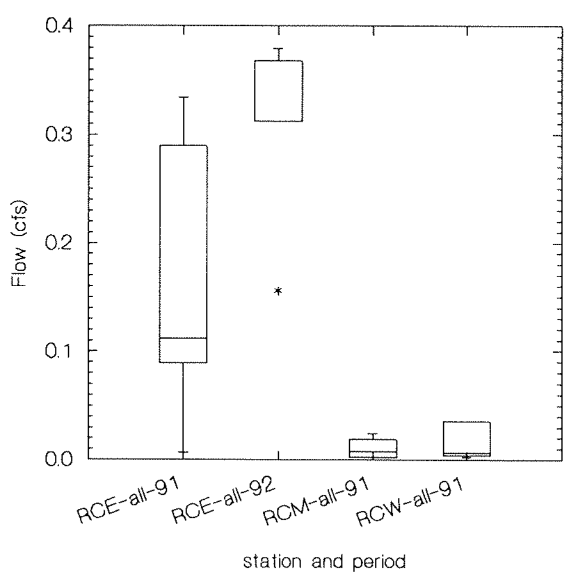

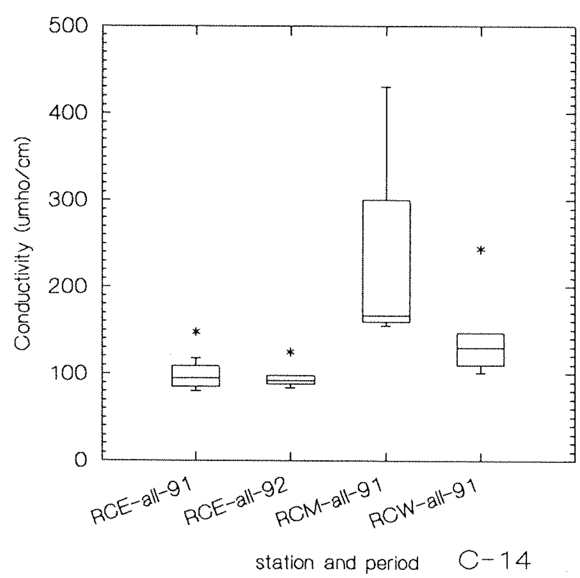

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